This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LANE MEDICAL LIBRARY STANFORD
2 45 0173 6895

FUNDAMENTAL PRINCIPLES OF
MECHANICO-THERAPY IN
HIP DISEASE.

Based on a Consideration of Clinical, Pathological and Physico-Physiological Data, with a description of New Forms of Elastic Tension Hip Splints.

BY

DR. MILTON JOSIAH ROBERTS,

Professor of Orthopedic Surgery and Mechanical Therapeutics in the New York Post-Graduate Medical School and Hospital, Visiting Orthopedic Surgeon to the City Hospitals on Randall's Island, Member of the New York Orthopedic
Society, Fellow of the New York Academy of Medicine,
Member of the American Association for
the Advancement of Science,
etc., etc.

EW

Read before the Medical Society of the State of New York, Feb. 6, 1884; *Reprinted from the Transactions of that Society for* 1885.

N. Y
1885

M 682
R 64

R64
1885
LANE MEDICAL LIBRARY
16111
SAN FRANCISCO

The Fundamental Principles of Mechanico-Therapy in Hip Disease.*

By MILTON JOSIAH ROBERTS, M. D., Professor of Orthopedic Surgery and Mechanical Therapeutics in the New York Post-Graduate Medical School and Hospital; Visiting Orthopedic Surgeon to the City Hospitals on Randall's Island, etc.

Upon my arrival at the Hospital of the New York Post-Graduate Medical School a few days since, I found, among the out-patients awaiting me, two with hip-joint disease. Both of them had been under treatment at my clinic for several months. When they first came under observation both were so crippled in consequence of the disease that locomotion was absolutely out of the question. To one, a short hip splint was applied; to the other, a long hip splint. Immediately thereafter and ever since these patients have been entirely free from untoward symptoms. The support rendered and force exerted by their respective splints at once relieved all pain and made locomotion not only possible, but comfortable. The consequence has been, that they have had the full privileges for play and out-of-door exercise which are ordinarily granted to healthy children.

The appliances worn by these patients were devised by me to carry out the mechanico-therapeutic indications which I considered to be present in their respective cases; the same, in fact, which I consider to be present in the vast majority of examples of this disease. These instruments were invented for special purpose of securing the *maximum degree of protection to the diseased areas*, without confinement of the patient in bed. Upon examination, they will be found to be widely at variance with the forms of apparatus hitherto constructed for this purpose. Not only do these instruments differ in form from those hitherto used, but they are constructed to carry out therapeutic ideas of exactly opposite polarity from those generally taught in this country or in Europe—ideas which, as applied to the hip joint in a modified and unelaborated form, were first enunciated,

---

*Read, by courtesy of the Business Committee, before the Medical Society of the State of New York, February 6, 1884; but, through inadvertence of the Secretary, not published in The Transactions of that year.

I am proud to say, by our countryman, Dr. Henry G. Davis, more than twenty-five years ago. For want of thorough elaboration and the full appreciation of their practical significance as well as for want of satisfactory mechanical devices with which to carry them out, these ideas have been almost forgotten. The facts, then, are as follows:

Two patients were before me who had been under mechanical treatment for hip disease for several months. They had been subjected to therapeutic measures, the value of which will be denied by most living authorities. Yet, from the inception of treatment up to that time, they had steadily and surely progressed toward a recovery looking to the *permanent re-establishment of the function of the joint.* Nor had either of them at any time during the course of the treatment experienced undue discomfort or pain. Furthermore, the histories of the two cases referred to only serve to illustrate the favorable results which have been obtained by the adoption of the same principles of treatment in many examples of analogous arthropathies.

Under these circumstances, it will be interesting to consider somewhat critically the various views which have been advanced regarding the principles of mechanical treatment in hip-joint disease.

Our information respecting the natural history of this malady and its principal clinical phenomena is in a very creditable condition, as the unanimity of professional testimony emphatically affirms.

When, however, we come to study the appearance of its therapeutic canopy, we find the vast dome occupied for the most part with catholicon nebulæ. Chirurgical constellations are only here and there dimly visible, and their relations to the signs of the phylacteric zodiac are so uncertain and capriciously varying that we are almost dispirited with attempting to make a reliable chart of articular therapy, and our remedial cognition seems irrevocably veiled in the lurid light of mysticism.

In undertaking to apply the scientific method to the solution of the difficult question before us, we must bear in mind that, before we can go beyond appearances and intelligently undertake to bring harmony out of apparent discord, we must review and afterward critically consider the concrete phenomena upon which the therapeutics of hip disease have been based; otherwise, we can never hope to rise above the information afforded by our senses. Let us, then, proceed at once to a review of the

THERAPEUTIC IDEAS DERIVED FROM CLINICAL SOURCES.

*Fixation.**—Fixation, or so-called "rest" of joints affected with chronic inflammation, is deemed by the mass of the profession to be one of the prime objects, if not the prime object, to be attained in their treatment. As applied to hip disease, it is perhaps the most universally accepted indication for treatment of any procedure in the whole domain of orthopedic surgery. To all who are studying this side of human disabilities in a scientific spirit, one or all of the following questions will sooner or later present themselves to their minds:

Whence came and what was the nature of the evidence upon which this dictum of "fixation" of chronically inflamed joints has been so firmly established? Is it the slow outcome of the scientific study of the therapeutic indications in hip or other articular disease? Is it the result of carefully planned, conducted, recorded, and subsequently studied experiments, either upon lower animals or upon human beings? Have sufficient clinical observations bearing upon this point been made by competent persons, recorded, studied, apparent exceptions satisfactorily explained, and all discernible sources of error studiously avoided, to place this idea so high in the esteem of the profession? Or is it another example of the firm support which blind credulity often gives to authority and to the ideas of antiquity? Can it be that the frequent reiteration of this dictum, unaccompanied by rational explanation or scientific demonstration, has been a sufficient basis upon which to erect a firm professional belief? Have we formed our beliefs first upon the statement of authority, considered the clinical and other evidence afterward with our eyes shut, and then declared all the testimony in favor of our preconceived notions?

---

*It is misleading to a clear conception of the question before us to use the words "fixation," meaning immobilization of the joint, and "rest" in the physiological sense, as synonymous terms. By so doing, not only an unproved but a demonstrably false hypothesis is admitted to be true, and will be sure to confuse or deceive both teacher and pupil. Again, a very common and equally calamitous error is the use of the word "rest," meaning the circumstancing of a part or the whole of the body in a condition favorable to the restitution of overworked, exhausted, or diseased tissues, as synonymous with "rest," meaning permanence of position with respect to surrounding parts.

I do not raise these questions in regard to the doctrine of fixation of chronically inflamed joints for the purpose of creating a sensation, nor have they for their object the stimulation of therapeutic incredulity. But, where there are so many conflicting statements as to the merits and demerits of certain therapeutic procedures, it behooves all of us who are earnestly searching after the truth to critically interrogate every statement and demand something more than mere *assertion* before we enlist ourselves under the command of any authority.

I speak deliberatively when I say we should demand something more than mere assertion; for, as members of a profession desirous of scientific advancement, we are at least entitled to an attempt at a rational explanation of therapeutic procedures, even though a satisfactory demonstration be not yet possible. That mere assertion is the favorite method of acquiring an audience and "explaining" (!) the *rationale* of the remedial measures advocated, the following quotations from high authorities, favoring the doctrine of "fixation" and selected from independent sources, will make manifest:

One author autocratically asserts that, "whatever may be the origin of hip-joint disease, the morbid state is kept up by movement of the joint." Neither preceding nor following this statement are to be found the data for its substantiation. Another asserts that "immobilization is indicated by every feature of the pathology as revealed in morbid specimens." Here again is a simple assertion, and unaccompanied by any explanation as to how it is that abolition of articular motion is such a potent factor in promoting reparative processes. A third author, on the ground of an extended personal experience and the occupancy of an authoritative professional position, seeks to convince his readers of the value of articular immobilization in hip disease solely by avowing it as his *belief* "that the closer one can come to securing perfect rest (fixation), the better the final result will be.

And so I might go on citing the *assertions* of authors advocating "fixation," and, so far as I have been able to learn, without finding in conjunction therewith sufficient reliable data upon which to found such a sweeping generalization. Now, while it is undoubtedly true that certain individuals possess an innate therapeutic genius, or are endowed with that still-higher mental quality of being able to *divine* trustworthy remedial measures far in advance of existing knowledge, this fact does not relieve them from the responsibility of earnestly endeavoring to discover the *rationale* of such measures for the benefit of humanity and the enlightenment of their professional brethren. The mere assertion that fixation of the diseased articulation should be the guiding star to our therapeutic endeavors is simply an evasion of the question, not a solution of it.

For the purpose of getting at the reliability and probable origin of the accepted evidence in favor of fixation, let us suppose ourselves before an aggravated example of hip-joint disease, the patient having not yet been placed under treatment. As he poses in his little chair, on the lounge, or in his mother's lap before us, you will observe him making use of his unaffected lower extremity as a splint for its disabled fellow. He is sitting or lying with his feet crossed, the usual position being with the foot of the unaffected limb placed behind that of the diseased member. The common interpretation of this observation is that the child is instinctively trying to "fix" his diseased articulation so that no motion of it can take place. Approaching our little patient more closely, he evinces a marked degree of apprehensiveness in his facial expression and general demeanor. Especially is this the case if he has been subjected to repeated examinations for diagnostic or other purposes. The apprehension of the little sufferer may be so great that he will even cry out before he is touched; or, if he is old enough and possesses the requisite courage, he will warn you not to touch him. What is the explanation of all this? The child has found that the slightest jar or motion of the limb gives him increased pain. He tells us that this is so, and it requires no great observational power to see that, under existing circumstances, he is right; for the merest disturbance of the limb at an unexpected moment will cause him to cry out with pain. Is there any conclusion more natural to arrive at than that motion of this articulation should be prevented? In the face of these observations, who has the courage to run the risk of being declared deficient in intelligence by asking for further proof of the truth of this conclusion? The history of articular therapy tells us that few indeed have possessed this courage, or at least thought it worth while to make the demand. Hence it is (no further adduction of evidence being called for) that the doctrine of "fixation" of chronically inflamed joints, based upon a so-called common-sense observation, without experiment and without demonstration, has arisen to the dignity in many quarters of being accepted as a therapeutic maxim.

Methods adopted to Fix the Hip Joint.—For the purpose of supplementing or replacing the supposed intended use of the unaffected limb as an immobilizing splint, and likewise the supposed retentive action of the reflexly contracting muscles, numerous means have been adopted to "fix" or immobilize the joint. These may be conveniently tabulated under two main heads:

I. The patient to maintain the horizontal decubitus.
  1. Supine or prone recumbency:
    a. Stationary; on an ordinary mattress or a special couch.
    b. Portable; *le grand appareil,* wire cuirass, etc.
  2. Recumbency and adaptable enveloping* (partial or complete) splints. Such splints pass unsegmented over the affected articulation, or are provided with an adjustable hinge opposite the joint. They are applied:
    a. En masse. Exs.: Leather, gutta percha, felt, thinly sheeted metal, etc.
    b. In laminæ. Exs.: Plaster-of-Paris, silicate of sodium, gum, starch, etc., in conjunction with cotton or other fabrics.
  3. Simple recumbency (without enveloping splints) and linear traction. The traction is exerted by:
    a. Weight and pulley.
    b. Coiled metallic springs or vulcanized rubber cords.
  4. Recumbency and non-enveloping† splints:
    a. Unsegmented. Ex.: Thomas's splint.
    b. Segmented. Ex.: Taylor's, Stillman's, etc.

II. The patient permitted to move from place to place.
  1. Enveloping (partial or complete) splints:

---

*All enveloping splints held in position, either by straps or roller bandages, probably owe their efficiency in overcoming reflex spasm more to circum-pelvic and circum-femoral compression, as will hereafter be explained, than to arresting motion of the joint.

†With this form of apparatus the limb is usually enveloped by a firmly applied roller bandage—an unrecognized though potent subduer of reflex muscular spasm.

- *a.* Unsegmented. Exs.: Plaster-of-Paris, gutta-percha, felt, etc.
- *b.* Segmented; with proximal and distal portions connected by an adjustable or non-adjustable joint. Ex.: Willard's hip splint.

2. Enveloping splints and crutches, or crutch and cane:
   - *a.* Without high heel and sole on shoe of foot of unaffected side.
   - *b.* With high heel and sole on shoe of foot of unaffected side.

3. Crutches, or crutch and cane, *without* enveloping or other hip splints:
   - *a.* With leg on affected side secured flexed at or near a right angle with the thigh.
   - *b.* With high shoe or patten worn on foot of unaffected side.

4. Non-enveloping splints, shafts of metal or wood, and with or without adjustable or non-adjustable joints.
   - *a.* With pelvic and femoral portions; single shaft along outer aspect of thigh to point above the knee.
   - *b.* Pelvic portion and single shaft on outer aspect of limb to a point just above the external malleolus.
   - *c.* Pelvic portion with external shaft to point under the foot.
   - *d.* Trunkal portion and external femoral shaft to point above knee.
   - *e.* Trunkal portion and lateral shaft to point above external malleolus, or under the foot.
   - *f.* Cervico-trunkal portion and external shaft to point above or below the foot.
   - *g.* Ischio-pelvic portions with external and internal shafts.
   - *h.* Ischiatic portion with single internal shaft.

In concluding this enumeration of the various means which have been employed to "fix" the hip joint, it should be observed that, for the most part, the substances made use of have been rigid, or of a non-resilient nature. Hence the quality of the support rendered must be very unlike manual support.

Extension (*traction*).—I wish now to call your attention to another therapeutic idea which has gained a wide acceptance. I refer to extension, or, to use a better term, *traction*, in the line of the deformity. Though the majority of physicians throughout the civilized world implicitly pin their faith to the one idea of fixation, a large number advocate traction in conjunction with it. They have found that, by taking hold of the limb with their hands and supporting it as nearly as possible in one position, and making general traction in the line of the deformity, the patient derives increased comfort therefrom ; and, furthermore, that the reflex muscular spasm appears to be more quickly overcome than when no tractile force is exerted. So there has been added to the original idea of " fixation " another one—that of traction (" extension ").*

Methods adopted for the Co-employment of Fixation and Traction.—To conjointly carry out the idea of articular immobilization and linear traction by the use of a single instrument, it was necessary to construct an entirely new system of mechanical appliances adapted to the hip and other important joints of the body. Numerous and exceedingly ingenious have been the means adopted and the instruments constructed for the co-employment of these two ideas, and the degree of perfection attained in the construction of splints for this purpose within recent years, especially in America, shows how earnestly and devotedly the subject has been studied.

To fix and make traction on the joint, the maintenance of the horizontal decubitus, in conjunction with diversified forms of adaptable enveloping and non-enveloping splints, as well as nearly every conceivable form of portable splint, segmented and unsegmented, in conjunction with crutches, with or without a high shoe—all provided with the means of exerting interrupted or more or less constant tractile force—has been brought into play. With one or two exceptions, however, all tractile hip-splints, while aiming at immobilization of the joint, have been constructed so as to exert only *rigid* linear traction, which possesses none of the resilient or elastic qualities of manual traction.

---

* The use of the word *extension* to convey the idea of the linear application of force tending to lessen intra-articular pressure is, as has been pointed out by Yale, Judson, and others, open to the serious objection of being more frequently used to convey the idea of that movement of a joint which opposes flexion. On the contrary, the word *traction* conveys exactly the idea which we wish to express, and no other. It, however, should only be used as a generic term, as will hereafter appear, and should be preceded or followed by a word or words designating the quality and direction of the tractile force.

Inquiry into the Therapeutic Significance of the Clinical Phenomena derived from an Examination of the Hip-Diseased Patient, and the Remedial Measures based upon them.—But let us approach our patient in a little more critical frame of mind. Let us interrogate every observation, eliminate all discoverable sources of error, weigh every conclusion, and, if, after all this, the result is the same as before, we shall at least have performed our duty as scientific physicians by not having permitted ourselves to form beliefs on the basis of casual observation.

Regarding Fixation. First, let us direct our attention to the idea of *fixation.* Remembering that

> "Errors, like straws, upon the surface flow,"

let us have the courage to ask, Was it the purpose of the little patient, or did he succeed in "fixing" his diseased hip joint by making use of his unaffected limb as a splint? Were not his efforts directed simply to affording *support* to a disabled member rather than to fixing the joint? What significance shall we attach to the existence of reflex spasm of the skeletal muscles passing over the affected articulation? Is it, as is ordinarily affirmed, an effort on the part of Nature to arrest the movement of the joint? Or is this approximation to articular immobility the incidental result of the contraction of muscles in obedience to the supremacy of a physiological law?*

If I take hold of the limb, gently grasping the leg just below the knee with one hand, while with the other, placed upon the mid-posterior aspect of the thigh, I exert additional manual support, I shall find that my little patient is deriving considerable relief therefrom. He no longer manifests a marked degree of apprehension. The transverse and perpendicular furrowing of the forehead is almost obliterated and his facial expression less anxious. Is this result a confirmation of the value of fixing the diseased articulation? It only requires the asking of a second question to answer the first, viz.: Is it possible for *human hands* to hold an object in a "fixed" position? With our hands it is an easy matter to very effectually *support* the disabled member; but we cannot exert a fixed or non-resilient force. A still greater augmentation of comfort on the part of the patient can be effected by making firm circumfemoral manual compression in conjunction with efficient support, thereby lessening myotic instability and reflex contractility.

---

* The law referred to recognizes the fact that all ordinary striated skeletal muscles are directly connected with, abundantly permeated by, and called into action through the mediation of nerves; and, furthermore, that, so long as the muscle retains its irritability, and the nerves connected with it preserve their conductivity, nerve stimulation must result in muscular contraction. Taking this physiological law for our guidance, and, bearing in mind the teachings of Mr. John Hilton and Schroeder van der Kolk, it is easy to account for the phenomena of reflex muscular spasm in hip and other allied articular diseases, on the ground that the delicate nerve filaments which are supplied to the muscles moving the diseased joint are derived from the same source as those passing into the area of bone involved by the disintegrating inflammation, and that these latter are unduly pressed upon or otherwise irritated, which irritation is transmitted along the course of the nerve-fibers to the muscles, giving rise to their involuntary contraction (shortening).

It may here be remarked that the explanation of the subduction of reflex muscular spasm by the application of a firm roller bandage, as referred to in a previous foot-note, over the contracting muscles, is to be found in the fact that the circumferential pressure thus exerted prevents the transverse bulging of the muscles—a necessary concomitant phenomenon of muscular contraction (shortening).

Relief to our patient came, then, not from immobilization of the joint, for with human hands it is impossible to accomplish this, but from effectually supporting the disabled member with a resilient prop and manually compressing the muscular bellies of the thigh and leg. Hence, to make the supporting part of our mechanical appliances out of *rigid* substances, with the avowed end in view of "absolutely fixing" the joint, can not be the result of a legitimate or logical interpretation of the fact just cited.

*The Fixation Dogma abrogated and Linear Traction with Motion substituted.**—But to continue with the examination of our little patient. While we hold the limb still in nearly the same position and make gentle traction in the line of the deformity, in conjunction with circumfemoral manual compression, he gradually, as already observed in our preliminary or non-critical examination, experiences a still greater degree of relief, and there is a partial or complete subsidence of the reflex muscular spasm. Not only have I rendered my patient much more comfortable than he previously was, but I now find that I can do with perfect impunity what was before absolutely impossible—viz., *make moderate movement of the affected articulation, and that too without the slightest discomfort to the patient.* Having overcome the reflex muscular spasm, I find, furthermore, that the amount of motion permitted is largely determined by the extent of *intra-* and *extra*-articular inflammatory infiltration. The greater the bulk of these products, the more do they act as a mechanical barrier to motion of the joint.

---

* In exerting linear traction upon a limb either by means of the hands or by means of strips of adhesive plaster applied to the surface of the limb, the tractile force, in all probability, owes its efficacy in overcoming reflex muscular spasm to dragging upon the muscles and thus offering a mechanical obstacle to their shortening. It thus acts as an adjuvant to circumferential compression.

Methods adopted for the Co-employment of Traction and Motion.—When the correctness of the foregoing observation had been established by numerous tests, there arose the idea of permitting motion of the joint during the continuance of linear mechanical traction. This observation was the signal for renewed exercise of mechanical ingenuity, and the avalanche of novel devices which followed bears emphatic testimony to the eagerness with which such opportunities are embraced. In the mechanical execution of this idea the changes have been pretty thoroughly rung on segmented enveloping splints and non-enveloping jointed splints, with or without crutches, all of which have provision for exerting linear traction and permitting more or less freedom of articular motion. Critically analyzing the quality of the force exerted by these appliances, we again see, as in the former instance, that, in nearly all, *rigid traction* has been substituted for *manual traction*, which, unlike the former, is resilient, tensile, elastic.

Recapitulatory Review of Mechanico-Therapy, and Summary of Conclusions based upon the foregoing Clinical Phenomena.—From our present standpoint we are able to see that that which was accomplished in our efforts to relieve the patient was not "fixation of the inflamed joint," but the affording of adequate though resilient support, it being physically impossible to immobilize the joint by manual efforts. It was thus demonstrated, by the simplest kind of an experiment upon the living human being, that the idea of "fixing" the joint, which has gained such a firm hold upon the the professional mind, has no foundation whatever in the clinical evidence adduced.

Had this analysis of the quality of the force exerted by human hands been made before surgeons began to devise means to mimic it, *rigid* splints would have been less commonly used. The tensile (elastic) support rendered by human hands, and demonstrated, as every practical surgeon knows, by thousands of satisfactory tests, to be so acceptable to the hip-diseased patient, would never have been supposed to have been successfully imitated by the use of such substances as plaster of Paris, iron, etc., made into heavy splints capable of affording only *rigid* support. The fixation dogma would have been nipped in the bud, and mechanical surgery would not have been throttled at its outset by the false interpretation of a commonplace fact.

In the second place, manual traction, like manual support, is resilient, tensile, elastic. In the execution of this idea by mechanical appliances, a fatal error becomes manifest. The tensile (elastic) linear traction exerted by the hands of the surgeon and repeatedly demonstrated to be all-sufficient for the relief of the patient, and for the rapid subduction of reflex muscular spasm, has, without its quality being analyzed, been replaced in nearly every instance by stiff iron or steel bars, the fixed points of which are separated by a screw, or by means of a ratchet and key, or by slotted bars held together by a screw and nut—mechanisms capable of exerting only *rigid* traction.

Thirdly, on taking hold of the limb of our patient, thoroughly supporting it, and making gentle traction in the line of the deformity, it was found that even an approximation to the immobilization of the joint was unnecessary to the comfort of the patient. Hence it was that surgeons who appreciated this fact sought to make use of it by permitting motion of the joint during the application of mechanical traction. Their object was to avoid the damaging influence of the long continuance of a close approximation to fixation of the joint, and especially the occurrence of ankylosis, a result almost certain to follow continued efforts of this kind in the treatment of chronically inflamed joints, the articular surfaces of which have become eroded. Here, again, surgeons, in nearly every instance, have clung to the enduring fallacy of substituting a rigid or non-elastic force for that exerted by the hands. By permitting motion, as has been done, under the influence of *rigid traction*, the results in some cases have been much more disastrous, in my opinion, than those incident to the employment of rigid fixation splints, or, at least, the employment of those that "fix" and rigidly tract the joint. My reasons for holding this opinion are as follows:

The articular surfaces of joints are not perfectly regular in outline. In health, the surface, though smooth, usually has an undulating contour. The hip joint, it is true, presents surfaces of nearly regular outline, and it is on this account, as will appear further on, that results in hip cases have been almost exclusively adduced in favor of the co-employment of rigid linear traction and articular motion. In moving the joint under the influence of *manual* traction and support, the tensile force exerted permits of the shaft following or adapting itself to the normal articular contours. Not so, however, when motion of the joint takes place under the restrictions of rigid *mechanical* traction. Under these circumstances we have a fixed point above and below the diseased articulation. Between these two fixed points extends a longitudinally adjustable rigid bar with a hinge opposite the affected joint. Increasing the distance between the two fixed points of lengthening this rigid bar in its adjustable portion will cause it to exert *rigid linear traction*. If now, during the continuance of rigid mechanical traction, the diseased joint be moved, it is plain to be seen that the articular surfaces can not perfectly adapt themselves to each other, for the force exerted by the instrument is rigid, and will not permit of motion outside the narrow limits prescribed by the mechanical hinge of the splint. As the path of motion, permitted by the joint of the splint, does not exactly coincide with that demanded by the affected articulation in order that motion shall not be disastrous to its integrity, there result, necessarily, more or less intra-articular pressure and friction from its movement under such circumstances.

It may have been the appreciation of this fact, though he has not so stated, which led Dr. D. Hayes Agnew to dogmatically assert that "motion without articular pressure or friction is simply impossible, and it is not in the power of man to make it otherwise." If *rigid* traction splints were our only means of making traction and permitting articular motion, I would willingly subscribe to the declaration of Dr. Agnew. But such is not the case. Instruments have already been devised and placed at the disposal of the profession which permit of articular motion under precisely analogous conditions to those demonstrated by an examination of the patient to be necessary in order that it should take place without giving rise to the least discomfort, or injurious "articular pressure or friction."

In view of these facts, it is rather remarkable that so sagacious observer as Dr. Lewis A. Sayre should make the fatal error of substituting *rigid* mechanical traction for *tensile* manual traction. More especially is this the case in view of the fact that his advocacy of articular motion, in conjunction with mechanical traction, is based upon the identical observation to which I have already called attention, viz.: *that, during the continuance of efficient manual support and traction, movement of the affected joint can be made without causing the least discomfort to the patient.*

We have, then, as a natural outcome of a mistaken interpretation of clinical facts, and at a great outlay of time, labor and money, a system—nay, more, systems—of mechanical appliances which, in the light of the foregoing observations, would appear to be wholly illogical and irrational. By the moderate exercise of our critical faculties we have now robbed the pet ideas *fixation* (rigid support) and *extension* (rigid linear traction) of their former cogency. We have shown that, if we are to make use of the evidence adducible from an examination of the patient as a basis for therapeutic procedures, we must first be certain of the *facts*, and, having demonstrated the reliability of these, should proceed to correlate them by finding out the thought which binds them together.

A brief but valuable lesson in the terminology of mechanicotherapy has been another result of our inquiries. It has been shown that the words support, traction, etc., can no longer be safely or legitimately used as specific terms, but must henceforth, as a result of an advance in knowledge, rank as *generic* terms, requiring qualification, when used, by such words as rigid, fixed, manual, elastic, tensile, linear, etc.

Again, in drawing our recapitulatory review of clinical phenomena to a close, we are brought face to face with the unpleasant reality that confidence in the prevailing systems of mechanical therapeutics as applied to hip disease is no longer justifiable.

Finally, we have deduced from clinical sources the following demonstrable facts:

1. That adequate resilient force can be applied to the affected limb of the hip-diseased patient without his experiencing in consequence thereof a feeling of irksomeness.

2. That artificial support the quality of which is tensile

(not rigid) is that which is indicated from an examination of the patient as desirable to be employed.

3. That resilient circumferential compression is a potent factor in overcoming or preventing reflex muscular spasm, and probably has more to do with its nullification than "fixation" of the joint, or even simple resilient support.

4. That elastic linear traction is the only kind or quality of traction that has been demonstrated from an examination of the patient to be serviceable, and that it is fully adequate in conjunction with resilient circumferential compression to the rapid subduction of reflex spasm.

5. That the combined use of efficient resilient support, firm tensile circumferential compression, and elastic linear traction, renders the patient more comfortable and more quickly subdues reflex spasm than the independent use of any one or two of these measures; and that, during the continuance of their conjoint use, articular motion can be made without the slightest discomfort to the patient, the extent of such motion after the subduction of reflex muscular spasm being largely dependent upon the bulk and consistence of the inflammatory products in and around the joint.

Therapeutic ideas based upon the above-mentioned facts would not be open to the serious objection of being illogical, irrational, and unscientific. But can we find no further evidence than that deducible from clinical sources with which to strengthen our developing therapeutics?

Before making further investigations, however, with the intention of strengthening our present remedial attitude, let us first see whither our compass now points, and in the next place investigate the conditions of the craft in which we are about to voyage.

THERAPEUTIC INTERPRETATION OF CLINICAL PHENOMENA.

The therapeutic ideas, then, which our critical clinical studies have served to inspire and to indicate the desirability of simultaneously executing, may be summarized as follows:

1. For the maintenance of the comfort of the patient and the avoidance of local irritation; the thorough artificial protection of the diseased area.

2. For the immediate nearest possible approximation to the condition of healthy local nutrition and the final perfect restoration of the functions of the diseased hip joint; the admission

of articular motion within certain limits, the nature and extent of which are to be at all times placed under the surgeon's control.

3. For the continued subduction of reflex muscular spasm and the prevention of intra-articular pressure and friction; the constant exercise of firm tensile circum-femoral and circum-pelvic compression and elastic linear traction.

4. For the maintenance of the general bodily nutrition at the highest possible standard; the non-interference with the performance of the functions of healthy joints.

5. For the purposes of locomotion and the sustentation of superimposed weight; the furnishing of sufficient artificial support to practically counterbalance the loss in supporting qualities on the part of the affected member.

6. For the avoidance of unnecessary incumbrance to the patient; the maximum degree of lightness of apparatus and ease of portability.

Though our training has been such as not to beget fright when new ideas are placed before us, we are not yet prepared to commit ourselves to these views, however plausible they may seem, for only a single line of evidence has been presented. One must needs be careful that his scientific beliefs be not formed too hastily or upon insufficient data. In medicine, as in other departments of knowledge, beliefs once formed, though afterward demonstrated to be erroneous, are hard to get rid of. If our therapeutic inferences be correct, they will lose nothing from an examination of other lines of evidence. Rather will they be strengthened and rendered more coherent. If they be false, the more evidence we examine the more difficult will it be to reconcile them with each other and with the freshly adduced matter. Hence our business, both for our own sake and the sake of medical science, is not now to attempt a practical test of these therapeutic ideas in the treatment of hip diseased patients, but to adduce further facts, and note if thereby they be strengthened or weakened.

What would be thought of a commander of a transatlantic steamship, though her past history had been entirely free from accidents, who, with a cargo of precious human lives, would set sail for a foreign port without being again assured that, though the ship and her engines had seen much service, a critical examination into their condition by competent parties gave emphatic promise of continued safety? Placing ourselves in this attitude to the question in hand, we are bound under heavy penalty, before proceeding farther, to inquire into the exact condition of the parts with which we are dealing; or, in other words, into the pathology of hip disease; not for the purpose of therapeutic inspiration, but for the purpose of therapeutic confirmation.

THE PATHOLOGY OF HIP DISEASE AND ITS THERAPEUTIC SIGNIFICANCE.

In adverting briefly to the pathology of hip disease, I am happy to avail myself of the *ascertained facts* bearing upon this point which have been laboriously collated by my friend Dr. A. B. Judson, and presented to the profession in a very instructive paper read before the New York Academy of Medicine.* Though these data were evidently collected under the impression that they supported the plan of treatment which I have designated in this paper as that of rigid support and rigid traction, they constitute, in my judgment, a most eloquent argument in confirmation of the feasibility of permitting articular motion at the hip, under the restrictions of efficient resilient support, firm tensile circumferential compression, and elastic linear traction.

The following illustrations and condensed extracts are taken from Dr. Judson's paper:

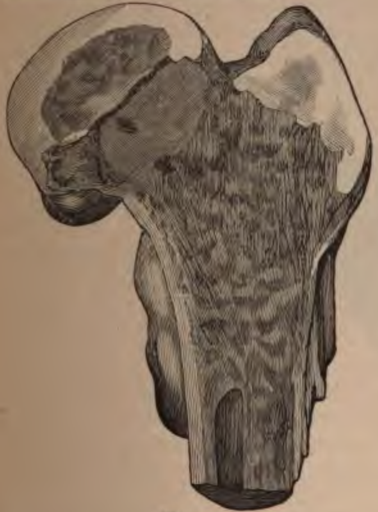

FIG. 1.

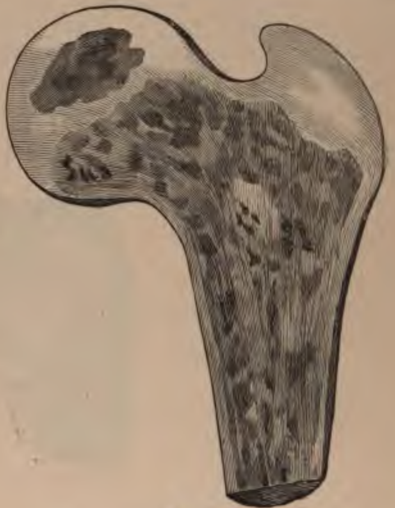

FIG. 2.

---

* "Some Practical Inferences from the Pathology of Hip Disease." *Vide* the "New York Medical Journal," July, 1882.

FRICK'S CASE, SHOWING LONGITUDINAL SECTIONAL APPEARANCE OF PROXIMAL END OF DISEASED (FIG. 1) AND HEALTHY (FIG. 2) FEMUR.—Boy four years of age, lame four months; died of tubercular meningitis. Synovial membrane everywhere red and congested. Articular cartilage healthy in all its surfaces. Increased redness and vascularity of spongy tissue of entire upper portion of femur over that of unaffected femur. In interior of neck and occupying the greater portion of same was a firm yellowish or grayish-white mass. Epiphysal cartilage much thinned.

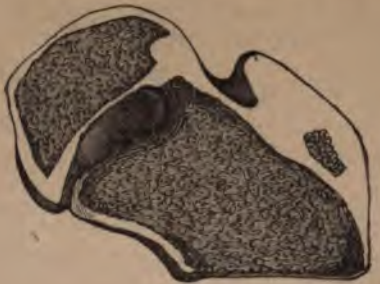

FIG. 3.

FIG. 3.—**VOLKMANN'S CASE.**—Cavity in neck of femur immediately under epiphysal cartilage, lined with a smooth tuberculous membrane and filled with cheesy matter. Large abscess between adductor muscles. Exsection. Recovery.

M. **LANNELONGUE'S CASE.**—A girl three-and a-half years of age died of diphtheria three-and-a-half months after coming under observation and five months after date of earliest symptoms. Synovial membrane in lower and posterior part presented a reddish, thickened and fungous appearance. Ligamentum teres red, vascular and slightly fungous. Surfaces of head of femur and acetabulum normal. Articular cartilages normal, except being thinned and less elastic in places. Section of head and neck of femur showed redness of center of ossification of head. Prominent feature of specimen was a cavity the size of a small bean, lined with a thin membrane, and filled with a cheesy substance, situated immediately below epiphysal cartilage. In some places fungosities started from membrane which lined the cavity and reached the surface of bone, where they became continuous with the thickened synovial membrane.

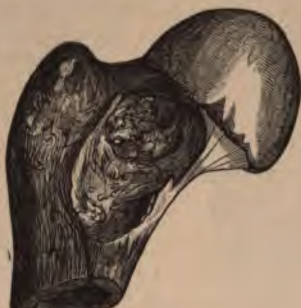

FIG. 4.

FIG. 4.—**MR. HOLMES' CASE.**—The disease is seen to be situated wholly in the neck of femur, where there is a deep carious cavity with some necrosed bone at the bottom ;

but the articular surface was quite healthy. The joint had been full of pus and the ligamentum teres was gone.

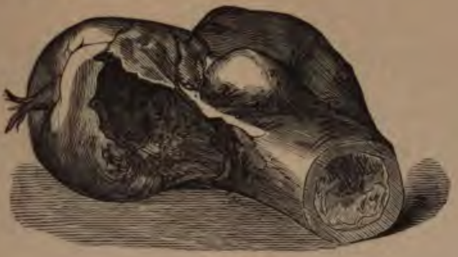

FIG. 5.

FIG. 5.—MR. BARWELL'S CASE.—Boy five years of age, died of tubercular meningitis about two months after the appearance of symptoms of hip disease. Remains of round ligament very thin, soft and shreddy; red and infiltrated with blood-stained serum. The epiphysal and diaphysal head of the bone with a portion of the neck was at its lower part quite carious; the excavation shown in the figure was, when fresh, filled with thick pus, mingled with bony detritus and soft granulation tissue. The cartilage was intact, though thinned, except around the carious cavity, where it had in great part disappeared; it was detached from the bone for a considerable distance around the margins of that excavation.

DR. HODGE'S CASE.—Neck of femur ulcerated through and but little remained of head, while articular cartilage remained sound and was attached to neck by periosteum on under surface. The articular cartilage of the acetabulum, and even the round ligament, was not diseased.

DR. POORE'S CASE OF FATAL DOUBLE HIP DISEASE.—Left joint contained no pus, the ligamentum teres was perfectly healthy; the cartilage on head of femur was white, glistening, and apparently healthy, except at a single point; the acetabulum showed no evidence of disease. There was found a carious spot about the size of a split pea, but of irregular shape, on the upper surface of the head, at a point just below the line of the epiphysal cartilage; the articular cartilage at this point was destroyed over a small extent; at this carious point there had been a circumscribed ostitis, or rather osteomyelitis, extending inward and upward from the carious point to a point just up to the epiphysal cartilage; there were other similar but smaller points of the same inflammatory process scattered throughout the head. The disease here was a central ostitis, which has involved the external shell of this bone of the head at one point only, and, had the patient lived, the joint itself would in all probability have been in time involved secondarily.

FIGS. 6 AND 7.—DR. GIBNEY'S CASE, ILLUSTRATING CENTRAL OSTITIS EXTENDING TO PERIPHERY.—Boy eight years of age who died of intercurrent disease several years after first appearance of hip disease. Right hip joint being opened, capsular ligament is found intact; no fluid within the cavity and suction force is normal, while ligamentum teres is easily detached. Head of bone presents dirty, yellowish aspect, with a groove extending from ligamentum teres toward trochanter minor, intersecting a similar groove about the insertion of capsular ligament. In this groove is new connective tissue. At one point cartilage is completely eroded; head flattened. On vertical section there appear three yellowish spots, two above and one below the line, of epiphysal union, which line of union is carried up one inch; cartilage is one-half the normal thickness, and this, as well as the bone underneath, is, in the field of the microscope, seen to be in the process of fatty degeneration.

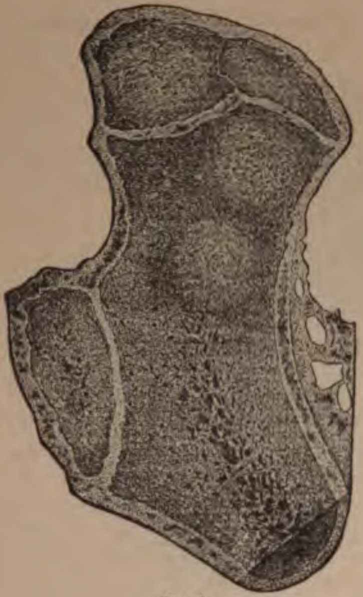

FIG. 6.

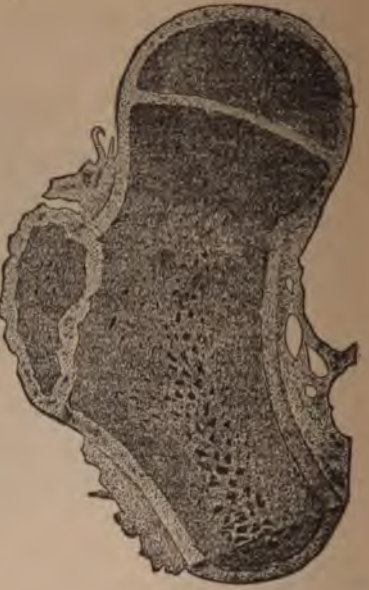

FIG. 7.

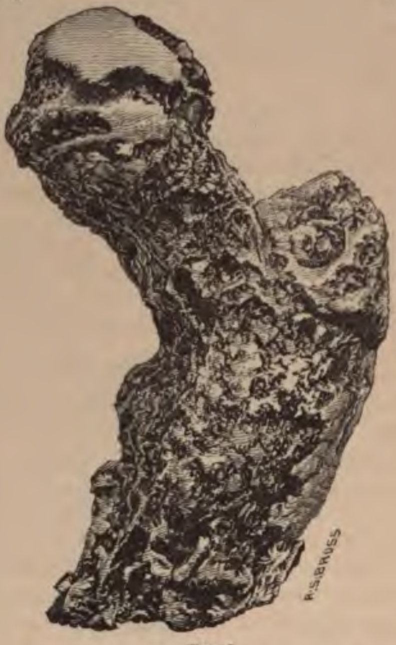

FIG. 8.

FIG. 8.—DR. SAYRE'S CASE.

Cut illustrates head, neck and four inches of shaft removed from boy fourteen years of age. Disease, as will be seen, is very extensive and yet there is a considerable area at the summit of the head which appears to represent the compact bony layer entirely unaffected.

The principal pathological evidence adduced in Dr. Judson's paper, and based upon actual post-mortem examinations, may be summarized in the following propositions:

1. The first morbid change in hip disease does not take place in either the femoral or acetabular articular surfaces.
2. The inflammation begins, as a rule, in the medullary tissue of the head of the femur and proceeds from within outward, involving secondarily the articular surfaces and the soft parts of the joint.
3. Abscess may develop prior to the involvement of the articular surface of either the femoral head or acetabulum.
4. Among the early changes subsequently found in the articular cartilages, and before their normal smoothness has disappeared, are their undue thinness in some places and deficient elasticity.
5. No specimens have been described in the literature of the subject which disclose erosion or ulceration on the surface of the bone or cartilage coincidently with a sound condition of the cancellated tissue.
6. The neck of the femur is almost invariably deeply ulcerated before the articular cartilage covering the head of the femur is involved by the disease.
7. The ligamentum teres is usually destroyed before serious erosion of the articular surface takes place.
8. When, as happens in the later stages of the disease, the articular cartilage begins to give way, the lesions found in it are insignificant in their extent and gravity compared with those of the underlying tissue.
9. Before ulceration or erosion of the articular surface takes place, there are clear evidences of the effects of pressure in the altered shape of the head and neck of the femur.†

Inferential Therapeutic Confirmation derived from Pathological Data.—It thus appears, from the pathological facts which we have had placed at our disposal, that, as a rule, neither the articular surfaces nor any of the soft parts of the joint (synovial membrane, capsule, etc.) are invaded by the disease until its later stages have been reached. In short, excluding the limited inflammatory focus in the head of the femur, the tissues entering into the formation of the affected articulation present no gross variations from the condition of health. Why, then, providing the comfort of the patient can be secured and his expeditious recovery insured, have we occasion, during the treatment, to deprive these healthy soft structures and articular surfaces of their function?

---

† *Loc. cit.*, Figs, 1, 3, 6.

The changes in the shape of the articular contour of the head of the femur are readily explained on the theory that there has been a continuance of its use for the purposes of support after its normal supporting capacity has been interfered with. This change manifestly results from the carious disintegration of its central portion, leaving, as it were, a shell of unaffected bony tissue with its incrusting cartilage, the free, smooth, rotund surface of which becomes depressed or flattened in places by undue pressure upon it. If, then, the supporting capacity of the diseased member be artificially re-enforced to the extent it has been interfered with by the inflammatory process, it is reasonable to infer that a change in the articular contour would not take place; for the super-imposed pressure upon the weakened femoral head, or head and neck, could not exceed its supporting power, however slight that might be. Granting that it is possible to furnish such artificial support, and bearing in mind that our pathological studies have revealed a carious interior of the femoral head, coincidently with a healthy condition of the articular surfaces as well as of all the soft structures of the joint, is it not a rational inference that, under the conditions determined upon in our clinical examination of the patient, motion of the joint can take place without damage to the diseased area? If so, the pathology of hip disease would seem to confirm in every particular the feasibility, at least in the early stages of the majority of examples of the malady, of attempting a practical enforcement of the remedial measures deduced from the study of its bedside phenomena. Tarrying to inquire into the pathology of hip disease, have we not encountered confirmatory evidence of the value of the remedial ideas gained from previous studies? Assured, then, as we are, of the harmony between the therapeutic conceptions derived from clinical sources and the exact pathological conditions with which we are dealing, the next step in logical order is the determination of the most expedient and scientific means of executing these ideas. That we may avail ourselves of the pertinent inferences to be made in this regard from a knowledge of the normal conditions, let us go to physiology, the fountainhead for therapeutic inspiration, and study her methods.

Just here I wish to say a word in self-defense; for, as hinted in the last sentence, I am about to invite your attention to lines of thought and observation which I am fully persuaded will be ridiculed by some as foreign to my subject, or at least having so little bearing upon it as to be possessed of no interest to the practical surgeon. To those who are familiar with the *method of discovery*, it is known that advance in the physical sciences as well as in medical science has achieved its most brilliant successes in consequence of investigations outside the narrow limitations of the concrete phenomena which inspired research. If, then, we are ever to be freed from the baffling maze of conflicting and contradictory opinions and practices which inthrall our understanding of the therapeutics of hip and other allied articular diseases, it is probable that much will be gained by a study of other avenues than the clinical and the pathological.

As already pointed out, the study of physiology bids fair to yield important results. In making a casual survey of the physiological field, however, the extreme complexity of the problems to be studied and solved is at once manifest—and so strikingly manifest, I confess, that, were it not for my enthusiasm for the subject, I would not venture to cope with it. The questions involved are so complex that, in order to make any headway at all in their solution, it will be necessary to separate them into their individual parts, and to consider these separately; in short, to adopt the analytical method.

PHYSICO-PHYSIOLOGICAL THERAPEUTIC DATA.

It will have been observed ere this that the path along which research in mechanico-therapy lies does not come to an end with the observation and careful consideration of clinical phenomena. Nor does it terminate with a knowledge of the site, extent, and nature of the morbid processes. It leads us beyond, to the study of the conditions of life in health, with special reference to those conditions of life in disease which we have observed at the bedside and verified at the post-mortem table. Standing, then, on the firm footing of a thorough familiarity with the clinical features of hip disease, and being assured of the favorable condition of the tissues of the disabled member for the practical execution of the therapeutic ideas which our clinical studies have inspired, let us seek to investigate those physiological questions which have a direct bearing on the ground gone over.

The one fact which our clinical observations have all the way along made paramount in our minds is that the hip-diseased patient requires artificial protection from disastrous traumatisms; and, furthermore, that efforts to avert such traumatisms must have special reference to protecting the area of tissue involved by the disease. That it shall be possible for us to proceed intelligently along this path, we must first know the source of such traumatisms. If the diseased area were located upon the external surface of the body, a very evident source would be direct contact with irritating substances, or blows on the affected area. Though it is not difficult to see how a direct injury to such an exposed focus of disease might result from voluntary muscular efforts, it is equally clear that the traumatisms to which it would be exposed must originate, for the most part, externally to the body. But the diseased area is not so situated. It is buried deeply beneath the soft parts in the head of the thigh-bone, away from the kind of traumatisms which superficial ulcerations of the soft parts fall heir to. Whence, then, come the traumatisms which it is the aim of treatment to nullify?

I think it will be universally granted that clinical studies have established the fact, that it is during the act of walking that the hip-diseased patient receives the traumatisms which for the most part prove so disastrous to him. Those due to terrestrial and other forms of transportation, though important to avoid, have a minor significance in this connection, for whatever means will successfully avert the former, experience has taught, will nullify the evil influences of the latter. It is, then, to the traumatisms of locomotion, or those resulting from the development of internal forces by an act of volition, that we must direct our attention. Our primary object will be to get some idea of the physical manifestations of these traumatic forces, together with a knowledge of the physical laws which preside over their destinies.

Physiological Dynamics. The Laws of Motion.—Turning our attention to the human body *as a whole*, recalling our individual observations and experiences, and applying the universally accepted laws of physics regarding the states of rest and motion, the following facts become manifest:—

The first of these is, that the body, being at rest, can not be set in motion or transported from one place to another without the application of *force;* likewise, the body being in a state of independent or artificial motion, either in respect to its individual parts or in passing from place to place, it cannot be brought to rest without again applying force.

Now, an established law of physics declares that *the application of this force can take place only through the mediation of some external body.* Internal forces can change the relative position of the particles of the body, but they are powerless to independently modify the position of the body *as a whole.* A man can not walk of himself across the street, but is obliged to use the pavement, ground, or some other object external to himself.

Though it is not possible for the position of the body as a whole to be changed without the agency of some external force, it is possible, upon the application of internal force, to throw one part of the body in one direction and another in the opposite direction. At first thought it may not appear perfectly clear how this is possible, but a little reflection upon what takes place during the act of walking will suffice to establish the truth of the statement. In the act of walking each leg is successively placed before its fellow, and the body is carried forward. It is generally stated by writers on bipedal locomotion that each step has two phases—one of *impact,* and one of *support.* To these it is necessary to add a third phase, viz., *the application of internal force in a backward direction.** As the foot meets with resistance upon the ground, and the body has at this instant a forward inclination, the application of internal force in a backward direction simultaneously results in a throwing of the body forward, or in the opposite direction from that in which the force is applied, and the truth of our statement becomes manifest. That the limbs are thus thrown out in opposite directions implies that they move with a given *intensity.* Now, upon the intensity of this action or movement and the bulk of the parts depends the *quantity of motion,* or *momentum*, as it is variously called. Again, applying one of the accepted laws of physics, we find that, whenever motion is developed from the application of internal force, the momentum of the parts moving in opposite directions is the same; or, to put it in more familiar terms, action and reaction are equal and opposite.

---

*This application of force is at first voluntary, but, once inaugurated, becomes automatic.

The Conservation of force (*Energy*),*—When we observe a man walking along the street, the movements continually developed for this purpose are arrested with each successive impact of the foot against the earth, and the force which produces them is apparently annihilated. But let us see if this is really the case. Is it any more feasible to create and annihilate force at pleasure than it is to create and annihilate matter? Nothing can be more certain than that visible motion has been arrested with each successive impact of the foot against the earth, and that a reapplication of internal force was necessary to produce successive movements. If, however, the subject of our observation walks heavily across the floor of the room in which we are sitting, a vibratory impulse is communicated to us, showing that, though visible motion was arrested by the impact of the feet against the floor, the force represented by the movements of the limbs was not annihilated, but underwent a transformation, after which it made itself manifest by a series of vibratory impulses or jars, imparted to objects external to the individual.

---

*In the present discussion, for reasons which will become evident as I proceed, I shall ignore altogether the one fact which is almost exclusively dwelt upon by writers on physics when it is sought to show that the energy of moving bodies is not destroyed by impact which arrests their motion. The fact referred to is the conversion of visible motion into heat in consequence of collision. Since Grove's first essay on "The Correlation of Physical Forces," the tracing of the sequences of impact has been confined to variously illustrating this fact, to which he was among the first to call attention, while the mechanical effects represented by the molecular vibrations in the colliding bodies have been almost wholly overlooked. In physiological physics a knowledge of these effects is of much greater practical importance in giving a clear insight into the subject—at least in its bearings on mechanical surgery—than are the less apparent thermic changes.

In studying the nature, cause, and effects of jars with reference to the human body, one is naturally led to expect material aid from a study of the laws of sound, for it is common knowledge that it is the vibrations of strings, membranes, and strips of metal and glass which result in producing musical notes or tones. With these effects of vibratory impulses, however, we have nothing to do. Those that concern us do not cause the vibrating bodies to communicate a part of their motion to the surrounding air in such a way as to give rise to audible undulations of it, producing sound. Curiously enough, almost the only analogous effects of vibrations to those that interest us which have been subjected to scientific observation and experiment are of seismic origin. We have, then, come upon a line of dynamic research which promises large returns to scientific medicine.

Again, suppose, instead of observing some one else, we direct attention to ourselves during the act of walking upon a level piece of earth, it being understood that our feet are clad in ordinary leathern shoes. By so doing we shall be able to appreciate a slight jar communicated to our body at every step. This jarring is so slight as to be unnoticed in health, unless particular attention be paid to it, By flexing the joints of the lower extremities to a greater degree than in ordinary locomotion, the jarring will be rendered almost imperceptible, even though particular attention be paid to detecting it. If, instead of walking on the ground, we walk in the ordinary way upon a stone pavement, the jarring will be much more apparent than in walking on the earth. Still more perceptible will it be if we do not flex our knee and ankle joints, so that we walk "stiff-legged," as it is termed. And, instead of walking on the stone pavement, should we increase our pace and run, we shall find the amount of jarring or shock to the body has been materially augmented. From these and the foregoing observations we are enabled to see that—

*The visible rectilinear velocity of the limbs during locomotion is converted by impact into molecular vibrations (known in common parlance as jars), which are imparted by the individual to the surface walked upon, and reciprocally imparted to and conducted back along the bony frame work of the body with each successive step.**

These commonly observed, reciprocal, kinetic sequences of the successive impacts of the feet against the earth serve to illustrate, in a very meagre way to be sure, the now universally accepted hypothesis among scientists, that the various manifestations of energy are correlated, and that force is indestructible. Hence we are justified in the assertion that, though there has been a transformation of force, the resulting mechanical effects of impact, summed up, point to the verifiable existance of an equivalency of energy.

Vibratory Impulses, or Jars, when severe or too long continued,

---

**Jars.*—The term jar is used to express not only a particular kind of sensation, which is appreciated more particularly by the sense of touch, but also the state or condition of matter which produces this sensation.

prove Disastrous to Healthy Tissues.—But let us regard still more fully the traumatisms resulting from voluntary muscular efforts. If the subject of our observation, instead of walking along the stone pavement, executes a series of jumps on two feet, he will find the jarring communicated to the body will be decidedly unpleasant, and, if continued long enough, will result in damage to healthy tissues. Or, again, should he engage in a severe contest of locomotor endurance, prolonged for five or six days, without sufficient sleep to permit of physiological repair, an acute synovitis of one or more of the joints of the lower extremities would probably result. Likewise, if he jumps from a great height to the ground, the resulting shock may even cause a fracture of some of his bones. From these and other observations which will readily present themselves to the mind, it follows that healthy tissues, though plainly in a less degree than diseased tissues, require protection from the vibratory traumatisms resulting from voluntary muscular action.

Again pausing to take our bearings and to see whither the path leads along which we have ventured, the probability becomes emphatically manifest that, by studying the means by which protection of healthy tissues from such traumatisms is normally accomplished, we may get some useful hints in regard to artificially furnishing protection to diseased tissues or joints, that being the goal for which all are striving. But we can not enter at once upon this inquiry. We must first pass over the ground which lies between us and it.

The Conduction of Jars through the Human Body.—For jars or vibratory impulses to damage healthy or diseased tissues, remote from the points of primary impact or collision with external bodies, implies that they shall be *conducted* through the body. By studying the conditions upon which the conduction of jars through the body depends, we again have promise of tangible data for therapeutic purposes.

To make the problem as simple as possible, let us study the conduction of jars through the body in repose. We have already incidentally regarded this point, when observing what took place when the body was in motion. First, let us inspect the healthy individual in the erect attitude, bearing equal weight on both feet. As he poses thus, we find the joint angles obliterated, and there is presented what is practically an unbroken column from the vertex to the soles of the feet. The long bones are placed end to end, so as to form nearly straight lines, and the curves of the spinal column are reduced to the minimum.

Under these circumstances the proportion of the weight of the body borne by the distal articular surface or surfaces of any particular joint varies inversely as the position of that joint in the series, proceeding from the soles of the feet toward the head.

From a study of intra-articular anatomy we learn it is in the erect position also that the greatest possible expanses of distal and proximal articular areas in the different joints of the body which can be utilized at any one time for sustaining the weight of the individual are firmly coaptated. In other words, the areas of contact between the ends of the long bones and those between the segments of the spinal column reach their maximum extent when the individual assumes the erect posture.

There is a twofold significance to this fact which only requires to be pointed out that you should appreciate it. In the first place there results an equitable distribution of the weight of the head and thorax between the vertebral bodies and their respective articular processes, while in each of the joints of the lower extremities the full quota of the superimposed weight of the body is fairly distributed over the maximum expanse of epiphyseal impingement. Secondly, as a result of the coaptation of the largest expanse of articular areas and the equitable disposition of the superimposed weight, we have the most *intimate and direct* contact of individual bones attainable in the human subject.

Opposed to the erect position, we have that in which the entire body is thrown into exaggerated curves and angles. The maintenance of such an attitude implies the coaptation of the least possible extent of articular contours. Not only is this the case in those joints into the formation of which the long bones enter, but also in the segments of the spinal column. By an exaggeration of the curves of the spine, the weight which is borne by the bodies in some of its parts in the erect position will be transferred almost entirely to the articular processes, while the reverse state of affairs will be found to exist in other parts of the spine. As a result, we have, in the first place, an *unequal* distribution of superimposed weight over the joint surfaces; and, secondly, the *least intimate* connection between individual bones attainable in the human subject.

Returning now to the erect attitude, let us make note of a commonplace fact, viz.: That it is in this position, standing squarely on both feet, with the trunk and extremities forming practically an unbroken column, and the greatest possible extent of articular areas applied one to another, that any jarring of the surface upon which the individual is standing, or vertical concussion communicated to the head or shoulders, is most readily appreciated, and, if considerable, causes the greatest amount of discomfort. The degree of concussion which in this attitude can be tolerated without discomfort is surprisingly small, and the amount necessary to damage tissue is not great. All of us have experienced the unpleasant jarring of the body incident to jumping from a slight elevation and alighting erect, "stiff-legged," as it is sometimes termed.

Let us now inquire into the reason why jars are so readily appreciated in the erect attitude. To satisfactorily answer this question it will be of service to formulate the law governing the conduction of the sequence of impact—vibratory impulses through the human body. This I venture to state in the following terms:—

The mechanical effects resulting from the conduction of jars through media depend upon the density of the media and the directness of their linear continuity; the denser the medium and the more direct its continuity, the greater its conductivity.

It is, then, to the denser or bony parts of the body that we must give our principal attention in studying the conduction of jars through it. In the erect posture, with the long bones placed end to end and the spinal curves approaching as nearly as possible a straight line, we have the maximum degree of linear directness, and, consequently, the maximum degree of skeletal or bone conductivity attainable in the human body. It thus becomes evident why the maintenance of this attitude renders the individual so vulnerable to such traumatisms as jars or concussions.

Nature's Protection against Vibratory Traumatisms.—We have now determined upon the source and the nature of the ordinary traumatisms which are to be avoided in hip disease. We have also learned that when these traumatisms are severe, or too long continued, healthy tissues may be damaged by them. And, finally, we have discovered the law which governs their transmission through the human body. Following out the legitimate sequence of these analytical findings, it will be our next business to study nature's means of protection against such traumatisms. The time allotted me will scarcely admit of more than mention of some of the more important physico-physiological factors connected with the avoidance of concussion or shock in the human body. The accomplishment of this object, in a greater degree than is possible in the erect posture, is absolutely necessary; otherwise the individual would be unable to successfully cope with the exigencies of every-day life.

Exaggerated Skeletal Curves and Angles as a Means of Protection against Jars.—In the accomplishment of this object, the hinge and ball-and-socket joints of the lower extremities, together with the mobile segmented spinal column, as might be inferred from the law just formulated, play a most important part. For it is by means of these that the direct linear osseous continuity of the erect figure, through the agency of the skeletal muscles, acting under the command of the central nervous system, can, at an instant's warning, be broken and decomposed into exaggerated curves and angles. The conduction of jars through the bones is thereby impeded by the obliquity of the impact of the molecular vibrations at the joint angles very much in the same manner as sound waves take longer to reach a given point when deflected from side to side than when they go in a direct line. In this way, in proportion as we interfere with the directness of skeletal continuity, do we lessen bone conductivity; and likewise, in the same ratio, do we prevent the unpleasant effects of traumatisms. We thus have a logical and rational physical explanation of the *modus operandi* of exaggerated skeletal curves and angles, and joints as a whole, in averting the evil effects of the inevitable traumatisms of human existence.

Application of Physico-Physiological Data.—The practical applications which I wish to make of physiological phenomena as they are successfully elaborated are twofold. In the first place, they are to be utilized for the purpose of testing the therapeutic value of the prevailing mechanical methods of affording protection to diseased hip joints. In the second place, I shall make use of them, in conjunction with the demonstrable clinical facts and confirmatory pathological evidence already tabulated, as basal factors in the building, it is hoped, of a more rational and scientific system of mechanico-therapy than we now have, not only for the hip joint, but for that extended list of chronic articular ailments which have so long been recognized as presenting an insoluble therapeutic enigma, and yet for the relief of which so much has been said and so little really accomplished.

Therapeutic Inferences derived from a Study of the action of Exaggerated Curves and Angles in Averting Jars.—Those of my hearers who have had the patience to follow me, and who are at all familiar with the so-called "principles" of the prevailing methods of treating hip and other joint diseases, will have no difficulty in recognizing the fact that we have already prepared the way, in some measure at least, for the removal of the mantle from mechanical surgery which has so long and so successfully concealed its leprosy from the eyes of casual and credulous observers.

It may be asked, and I confess, at first blush, with apparent good reasons, Why have you, in considering the therapeutics of hip diseases, finding it advantageous to refer to functional and structural articular details, extended the scope of your inquiries so as to include all the joints of the lower extremities and spinal column as well?

My reply is, Had physicians confined their mechanical treatment to the hip in hip disease to the extent, at any rate, of not seriously interfering with the functions of healthy joints, it would have not been necessary for me in this paper to have laid so much stress upon the function of other joints than the hip. But when recognized authorities—as, for instance, in our own country, Dr. Lewis A. Sayre, and in Europe Mr. Hugh Owen Thomas—will for years persist in the promulgation of views so illogical and inconsistent that they can neither be harmonized with the clinical facts nor with each other, the time has come when some one possessing the courage of his convictions should step to the front in the name of progressive medicine, with a few pertinent correlated facts, in the hope of opening the eyes of credulous hero-worshipers and other willing victims of delusive and unsubstantiated assertions.

When a recognized authority, observing that "by placing the hand upon the pelvis" of the hip-diseased patient, "and making gentle extension upon the limb for a few seconds in the *line of the deformity*, motion can be made at the joint without causing pain"; when, furthermore, he declares that "*motion* is as essential in retaining a healthy condition of the structure about a joint as light is essential in retaining a healthy condition of the eye"; I say when, in the face of such statements as these, he deceives himself and his credulous followers into supposing, in the first place, that he is closely approximating the kind of force exerted by his hands by substituting for it a *rigid* bar "reaching from the pelvis to the bottom of the foot," and provided with a mechanism capable of exerting only *rigid traction*; when, in the second place, he lashes, as it were, the entire lower extremity on the affected side to this rigid shaft by attaching it to the limb at the top and bottom and then slipping "the knee-pad band up or down until it is made to rest opposite the knee, when it is passed around the leg and buckled"; when also, in the face of such practices, he declares in a previous paragraph that he "can see no propriety whatever in restraining the movements of this joint" (the knee); when, I repeat, such conflicting statements and practices as these have been enthusiastically and effectively promulgated for years—the time is ripe for no longer tacitly acceding to the credibility of illogical dogmatisms simply because they may appear to have acquired a prescriptive right to our indulgences.

But let us calmly study the salutary remedial lesson to be derived from our knowledge of the action of exaggerated curves and angles in the human body in averting the mechanical effects of jars. We found, in the first place, that the conduction of jars through the body when at rest was most readily accomplished when the individual was in the erect posture, standing squarely with equal weight on both feet; or, in the terms of our formula, during the continuance of the maximum degree of linear skeletal directness. In the second place, we found, when the direct linear osseous continuity of the erect figure was broken and decomposed into exaggerated curves and angles, that a very remarkable degree of protection against traumatisms was secured, the explanation being that the progress of the vibratory wave was interfered with by the obliquity of impact at the osseous angles and curves. That exaggerated osseous curves and angles lessen bone conductivity does not imply that the maintenance of this attitude, partially squatting, is essential to the safety of the individual, but simply that it is desirable that such an attitude can be assumed when occasion requires. The indication to assume this attitude is derived from the information afforded by our senses.

Hence it will readily be seen that, in hip disease, to make use of a rigid shaft which passes over all of the joints of the lower extremity on the affected side, to which the limb is lashed, as is customarily done, would be an insuperable barrier to the utilization, in the face of danger, of a remarkably effective normal method of joint protection. Nature's column, capable of instantaneous angular decomposition, is by this means placed in the perilous attitude of permanent linear continuity. The conditions for the conduction of jars are at their maximum degree of perfection, and it matters little whether or not the site of impact be transferred from the foot to the perinæum.

But the greatest triumph of mechanical non expertness in the treatment of hip disease from the physiological standpoint, is that elaborated by the far-reaching genius of Mr. Thomas, of Liverpool. In his efforts to remove his therapeutics as far as possible from physiology, he has probably reached the highest degree of divergence; for not only does he strive to immobilize the hip and knee joints, but also to abolish motion, as far as possible, in the spinal column up to the level of the lower angle of the scapulæ.

It would be interesting instruction to examine the illogical and unscientific details of this and other plans of treatment advocated for hip disease, but the scope of this paper forbids more than a suggestion in this direction.

The question which next arises, then, is whether exaggerated curves and angles are the only means Nature has for protecting herself against traumatisms?

Facts Pointing to Additional Normal Means of Protection Against Jars.—Again recalling our individual experiences, we know it is possible, with the body still in the erect attitude, to very completely nullify the ordinary jars communicated to it, by simply rising upon tip-toe. This is an every-day experience, and it is the method which is usually adopted to interfere with the conduction of jars through the body, when, riding in any vehicle, a very rough piece of road is encountered. In cities, it sometimes happens that a street-car is thrown from its track and drawn a considerable distance over the rough stone pavement. On such occasions, in order to avoid unpleasant or injurious jarring, it is not unusual for all who are in the car to suddenly rise to their feet, assume the erect posture and stand on tip-toe until the car is placed back on the smooth track.

Certainly, the avoidance of jars by such a measure could not be explained on the ground of the non-conductivity of the skeleton due to interference with its linear continuity. We are thus forced by this single, unexplained fact to take up a new line of inquiry. To proceed intelligently we must first get at the facts in the case. In order to maintain the figure erect and rise upon tip-toe, it will be seen that a *voluntary muscular effort* must be made. Upon recalling what took place in the illustration first cited, we see, also, that the muscles, under the voluntary guidance of the central nervous system, played an important part in throwing the body out of line. Did they not accomplish something more than this? These unsatisfied queries unmistakably point out the fact, that we have not yet considered all of the important factors connected with the abolition of shock, or the interference with the transmission of vibratory impulses through the human body. That we may not attach undue importance to exaggerated skeletal curves and angles as agents in avoiding shock, let us squarely face the not altogether simple problem of ferreting out the remaining significant physical factors connected with this interesting subject. These can then be utilized, in conjunction with those heretofore established in determining upon a more comprehensive, rational and scientific explanation of the protection of healthy tissues from disastrous traumatisms than the results of our studies thus far will permit. When we have accomplished this, we shall be in a better position to consider the therapeutic applicability and significance of the principles thus determined upon; and to undertake their practical application to the protection of the tissues involved in hip diseases, should they give promise of remedial worth.

Muscles and muscular force as protective agents against Jars.—Recalling the observation indicated in a preceding query, it is plain to be seen, that upon throwing the erect figure into exaggerated curves and angles, a constant muscular effort is required to retain it in this position. It is also clear that while thus retained, the sustentation of the weight of the body, can no longer depend principally upon the bones. Especially is this the case in the lower extremities where the shafts of the long bones do not now correspond or lie parallel to a line indicating the center of gravity. Likewise, to maintain the erect figure on tip-toe, requires a constant muscular effort. Now as the continuance of either of the above attitudes necessitates a persistent muscular effort, and furthermore as both attitudes secure for the individual a remarkable exemption from the unpleasant or evil effects of jars, we are justified in the inference that muscles and muscular force have largely contributed to this most satisfactory result. Such an inference is so fully in accord with the individual experiences of every-day life as to possess no innate improbability.

We have now, therefore, to turn our attention to the physical explanation of how muscles can be utilized for the purposes of avoiding shock. The first step in this inquiry is to note some of the physical properties of living muscle. In reviewing these it will only be necessary to mention those which have a direct bearing upon the subject in hand. One of its most important physical properties, and that which particularly interests us in this connection, is its *elasticity*. It differs from bone in possessing less density and stiffness, and greater resilience and pliability. It is also possessed of a constant tendency to contract, which condition is familiarly known under the name of *tonicity*. When called into forcible action by the application of a proper stimulus, the force exerted, as already determined from our clinical studies, is *elastic*, *tensile*, *resilient*.

But how are we to make use of our knowledge of these physical properties of muscle in explaining the nullification of jars? Without entering upon the easy task of its rational establishment or detailing its experimental proof, a fundamental theorem may be stated which will clearly point out the way. It is this:

When the properties of matter are manifested, be they general, as elasticity, impenetrability, etc., or specific, as hardness, pliability, etc., their mechanical effects are the same, whether the bodies belong to the organic or inorganic world, if to the organic, whether they be living or dead, of the animal or vegetable kingdom, if to the living animal, whether they are manifested or not in consequence of voluntary efforts.

It will thus be seen that the question has now narrowed itself down to the physical explanation of the nullification of jars, by elastic bodies. To satisfactorily answer this question, it will be necessary once more to summon to our aid some of the exact knowledge of physics.

Laws governing Collision or Impact.—One of the general properties of matter is its *impenetrability*. When, however, two bodies come into contact in such a manner, that one tends to occupy the space which is occupied by the other, there is a reciprocal action developed which results in a change in the conditions of motion, and it is this mutual action which is called *impact or collision*. Now it is evident that the jarring of the human body which we are considering, implies the question of impact or collision with some object external to it. When collision between two bodies takes place, there results more or less mutual compression. If afterward they resume their original shape, their *perfect elasticity* has been demonstrated. Should they undergo more or less permanent change in form, they would be *inelastic*, or *imperfectly elastic*, as the case might be. A discussion of the impact of bodies of various degrees of elasticity and density would be instructive, but I shall be content for the present, by quoting the conclusions regarding impact, which are accepted by the best authorities on theoretical and analytical mechanics, viz.:

" In the impact of perfectly elastic bodies no vis viva is lost.

"In the impact of imperfectly elastic bodies, vis viva is always lost, and the greatest loss is suffered when the bodies are perfectly non-elastic."*

These formulæ state the facts which underlie the use of elastic bodies and the force exerted by them for the purposes of interfering with the transmission of vibratory impulses. From them we gather the important truth, that collision with a perfectly elastic body, does not result in setting up a violent molecular agitation in the form of vibrations which are propagated throughout its entire extent and communicated with little loss to elastic bodies with which it is intimately connected. If such were the case, jars would be as readily appreciated on tip-toe, as in the erect posture when the individual is standing squarely upon both feet ; for the muscles would be called upon to transmit to the bony frame-work whatever jars were communicated to them in consequence of impact. What really takes place as a result of impact with an elastic body, then, is that the force of the collision is first spent in compressing the elastic body, after which, during the second period of impact, it expands until it has acquired its original form, and in doing so, the elastic body restores all of the energy expended in the first stage of impact, when it was being compressed, and there results, therefore, *no loss of vis viva.* When collision with an imperfectly elastic body takes place, there is always a loss of *vis viva.* In the example cited, where the individual is walking upon a stone pavement, the sum of such loss is represented by the molecular disturbance of the surface walked upon and the reciprocal molecular disturbance imparted to the body of the individual.* We are also able to state a further truth, viz: that, directly in proportion to the elasticity and bulk of the colliding body, do we find immunity from the linear conduction of jars. The unity of elasticity of muscle being considered the same, this statement explains why a well-developed muscular man can submit with impunity to impacts resulting in jars, which would be almost if not quite fatal to a "living skeleton" such as are sometimes placed on exhibition in museums.

---

*"The Elements of Analytical Mechanics." By De Volson Wood ; New York, 1884, p. 61.

We have now accomplished the self-imposed task of erecting a rational and scientific finger-post, pointing out the *modus operandi* of muscles and the force exerted by them, either alone or conjointly with exaggerated skeletal curves and angles, in averting the evil effects of traumatism to healthy tissues near to or remote from the points of impact.

Therapeutic Inferences derived from a study of the action of muscles and the force exerted by them in averting jars. The therapeutic inference derived from a study of the action of muscles and the force exerted by them in averting jars, may be summarized in the following propositions:

First. For the purpose of restoring *voluntary* use of the muscles, the early subduction of reflex muscular spasm.

Second. That the voluntary movements shall correspond as nearly as possible to those in health, the artificial support used should be constructed in imitation of the physiological mechanism.

Third. To overcome the feeling of insecurity incident to a flabby condition of the muscles, muscular tonicity should be artificially restored.

---

* It is this latter molecular disturbance that proves so disastrous to the hip diseased patient. The molecular disturbance imparted to the body varies in degree in different parts of the skeleton. The site of its greatest severity is probably the determining factor in the location of the initial inflammatory focus in examples of epiphyseal ostitis.

Fourth. In order to secure the benefits derived from bulk and normal elasticity, muscular atrophy should be prevented in so far as possible.

Is the circle of evidence complete? I fear I have already exhausted your patience by so long tarrying to discuss the fundamental principle of physiological physics underlying the building of a scientific therapy for hip disease. Yet I cannot help indulging the belief, that the end in view, justifies the course I have taken. Bearing in mind the plan which has thus far been so successful in pointing out and leading to the formulation of new truths, be we ever so weary, the demand becomes imperative, that we should pause at the close of our consideration of each successive idea to inquire whether the circle of evidence is complete. So now, we must ask the question have we included in our studies all the important physico-physiological factors connected with the avoidance of jars to healthy tissues?

Regarding the general structure of joints.—Without casting about for phenomena in connection with the avoidance of jars in health which cannot be satisfactorily explained by any of the facts yet adduced, let us proceed along a shorter path by making some direct inquiries regarding joints to see if anything attracts our attention which has thus far been overlooked. The facts elicited when searching for a physical explanation of the operation of exaggerated curves and angles in averting traumatisms as well as certain other attitudes maintained by voluntary muscular effort give a degree of directness to our present line of questioning; for we are at once able to see that our time will be more advantageously employed by confining our attention to the general structure of those movable joints which are called upon, when the individual assumes the erect attitude, to bear the weight of the body; these are the articulations of the spinal column and the lower extremities. More narrowly still do the aforesaid facts enable us to restrict our anatomical inquiries without the slightest probability of overlooking important structural data, for again, it is equally clear, that we have only to do with the *physical properties* of the component tissues of joints, and with those only in so far as they have a direct practical bearing upon the *conduction or non-conduction of jars* through the human body.

For our present purposes sufficient detail will be insured by considering joints as composed of *muscles, bones, ligaments and cartilages*, to the exclusion of capsules, synovial membranes, blood-vessels and nerves. We have already considered somewhat fully the part played by bones and muscles and *joints as a whole* in the conduction of vibratory impulses through the body. These may therefore be dismissed without further notice. We have left, then, for consideration only those articular tissues comprised under the terms ligaments and cartilages.

The Physico-Physiology of ligaments.—The bones of all the movable articulations of the spine and lower extremities are held together by very strong but pliable bundles of fibrous tissue. With reference to those physical properties with which we are concerned, these bundles of fibrous tissue may be conveniently divided into two classes:

First, those which are composed of *white fibers* lying parallel or across each other. Ligaments of this class, whether capsular, lateral or interarticular, are *non-elastic*. They serve to hold the intra-articularly opposed surfaces of bones in accurate co-aptation whether the skeletal continuity be direct, as in the erect figure, or thrown into exaggerated curves and angles, as in the squatting posture. It is the tension of these ligaments, also, which arrest the movements of joints before the margins of the bones come so near to each other as to touch. While their pliability permits of perfect freedom of articular movement they are so strong and inextensile as only to yield under extraordinary strain.

Second, those which are composed of *yellow fibers*. Ligaments of this class are *elastic*. They (ligamenta subflava) are only found between the adjacent vertebral arches, which they serve to tightly connect. Their elasticity however, renders it possible during anterior flexion of the spine to very considerably increase the distance between any two adjacent arches. In addition, the extensibility of these ligaments, permits of lateral and twisting movements. It is this same property, also, that aids in the restoration of the spinal equilibrium after it has been disturbed by muscular action.

Therapeutic Inferences regarding Ligaments.—The foregoing statements considered in the light of our previous studies, make it evident that ligaments belonging to the first class (inelastic) do not play an active part in affording protection against jars. They are, however, passive agents, permitting, by their great flexibility, of the movements of the bony segments upon each other necessary to interfere with the linear directness of the skeletal continuity. It is therefore important that their pliability be not interfered with by long continued abolition of function.

With regard to ligaments of the second class, we are justified in the inference that, being composed of *yellow elastic tissue* and possessing the resilient properties of muscular tissue, they operate in proportion to their bulk and the degree of their elasticity, very much as do muscles in averting the evil effects of traumatisms. Whatever virtue they possess in this regard, therefore, should not be annulled in the hip-diseased patient by confining the movements of the spine to such an extent as to interfere with their normal operations.

Physico-Physiology of Cartilage.—In considering tissues as protective agents against concussions, our physical studies have taught us to regard them principally with reference to the degree of *elasticity* which they possess and their ***bulk***. The greater the elasticity of any tissue and the greater its bulk, the greater will be its service as a protective agent to tissues lying beyond it.

With these ideas in mind, a study of cartilage, as it is found in various parts of the body at different periods of life, enables us to make a double classification of it as follows:

With reference to its *properties*, we have first to consider that kind of cartilage known as *hyaline*. Investing the articular extremities of bones, it provides an exceedingly smooth service designed to lessen the friction of motion to the minimum. Having no earthy salts in its composition, it is not as hard as bone and is much more elastic. The depth to which it covers the ends of bones varies at different points according to the amount of pressure to be borne.

A second kind of cartilage is that known as *fibrous*. As its name indicates, it is characterized by the physical properties of fibrous tissue and ordinary hyaline cartilage, combining the strength and flexibility of the one with the elasticity of the other. Flattened masses of this kind of cartilage, of considerable but varying thicknesses, having irregular contours and smooth free surfaces, are sometimes found interposed between the ends of bones. Their flexibility renders it possible for the movements of the joint to take place without interference, while their elasticity serves as a buffer to deaden the effects of concussions. These inter-articular fibro-cartilages are only found in joints which are normally subjected to frequent and violent movements.

Another variety of fibro-cartilage is that known as the "connecting." It is this variety which connects the adjacent surfaces of the vertebral bodies together. These intervertebral substances, as they are called, though not permitting of any gliding motion between the vertebral bodies, owing to their great strength, flexibility and elasticity, render the column at once strong, freely mobile and autoequilibrious: It is in short, one of the most remarkable compact buffing-apparatuses to be found in the whole range of animal mechanisms.

With reference to the quantity or *bulk* of cartilage, another classification is necessary. This necessity is consequent upon the fact that the quantity of cartilage present in the body varies with the age, or stage of development, of the individual. During prenatal life the principal part of the skeleton is cartilaginous; some parts, however, are membranous, as for instance, the cranial bones. Even during the early years of postnatal life the proportionate bulk of cartilage still far exceeds that found in the adult. Finally the processes of intramembranous and intra-cartilaginous ossification having been completed, the bulk of cartilage in the body is reduced to the minimum. There still remains, however, some cartilage which does not ossify as already pointed out when speaking of articular and inter-articular cartilages. Hence the necessary division of cartilage into *temporary*, or that which subsequently becomes ossified, and *permanent*, or that which persists during life. Bearing in mind the high degree of elasticity possessed by cartilage and the physical explanation of the use of elastic bodies in averting jars, it is clearly manifest how young children sustain with perfect impunity concussions or jars which would result in serious disturbances of the brain or cord, or even fracture of bones in adults. It will thus be seen that as the individual advances in years, the normal means of protecting delicate nervous or other structures from the evils of vibratory impulses or concussions, steadily decrease from birth until the chondrified skeleton has been entirely replaced by the bony skeleton.* Hence the adult is forced to exercise greater caution in his movements than the youth. Were he to indulge in the reckless gymnastics of childhood, he would soon come to grief.

---

*Nor does the decline in the normal means of protection stop here. With advancing life the proportions of earthy salts in the bones increases and renders them more brittle; explaining the well-known easy fracture of the bones of old people.

Therapeutic Inferences regarding Cartilage.—In meditating upon the utilization of cartilage for therapeutic purposes, it is evident, that the same general conditions must be fulfilled in regard to it, as for other tissues when utilized by the surgeon for a similar purpose, viz.: *that its physiological integrity be maintained as near the normal as possible; and in the second place, that there be no artificial barriers erected preventing a fulfillment of functional engagements.* Hyaline and fibrous articular cartilages should therefore not be submitted to long continued intra-articular pressure due to reflex muscular spasm or other causes, thereby diminishing their thickness and rendering them brittle. A continuance of their smoothness and elasticity, if articular, should be promoted by permitting motion, at least to the extent already determined upon when studying clinical data.

The enormous bulk of temporary cartilaginous tissue made use of by nature during early life in averting jars should still be made to serve in the hands of the surgeon who treats the hip diseased patient, the excellent purpose to which it is so admirably adapted.

These therapeutic conceptions regarding cartilage are wholly ignored by that large number of surgeons who use rigid traction splints extending from the pelvis to a point beneath the foot where the successive impacts in walking are received and the resulting jars transmitted undiminished along a rigid iron shaft to the thin layer of tissues overlying the ischium, a bone in close relation with the diseased femoral head. By such an arrangement, not only is no opportunity offered for the nullification of jars by the permanent and temporary cartilages of the affected lower extremity, but the traumatisms of locomotion are directly transmitted to within a very few inches of the diseased focus and received at a point, interposed between which and the inflammatory area, there is almost a direct bony connection.

The cartilaginous tissues may be utilized in disease not only to aid the muscular and other structures in averting jars, but to aid though in a less degree than in health, in sustaining the weight of the body when the individual is in the erect attitude, thereby requiring less tractile force to be exerted than is necessary for the purposes of locomotion when the impact of the step on the diseased side is received on the foot-piece of a rigid traction hip splint.

THE PRACTICAL APPLICATION OF THE THERAPEUTIC IDEAS RESULTING FROM THE FOREGOING INQUIRIES.

We have now reached a point where we can separate from appearances the truth which the prevailing systems of therapeutics contain, and appreciate the significance of the fundamental principles of a scientific therapy for hip disease. We may, therefore, with advantage, proceed to the consideration of those means which are at our disposal for the practical realization of the therapeutic ideas which have resulted from our studies.

These ideas may be formulated as follows:

First. The maximum protection of diseased areas from disastrous traumatisms.

Second. The furnishing of sufficient artificial support to counterbalance the loss of supporting power on the part of the affected member, thus permitting the patient to walk about.

Third. The prevention of intra-articular pressure.

Fourth. The nullification of reflex muscular spasm, and the restoration of voluntary muscular power.

Fifth. The placing of the movements of the diseased articulation under the control of the surgeon at all times.

Sixth. The maintenance of the general and local nutrition of the patient at the highest possible standard for the purposes of general growth and the repair of the diseased tissues.

Seventh. The non-interference with the performance of the functions of healthy joints.

Eighth. The use of self-acting mechanisms as far as possible.

Ninth. The avoidance of unwieldy apparatus.

Fig. 9 illustrates the appearance, when applied, of one form of hip splint which I have invented to carry out the principles of mechanical treatment which have resulted from the foregoing inquiries. It is recommended in those early cases where only a moderate amount of sustentation is required, or where convalescence is well advanced. It can be used with advantage also, only when the patient possesses a long thigh, that it may be thoroughly attached.

As will be seen, the instrument consists of a pelvic and a femoral segment. The former is made of very thin sheet steel

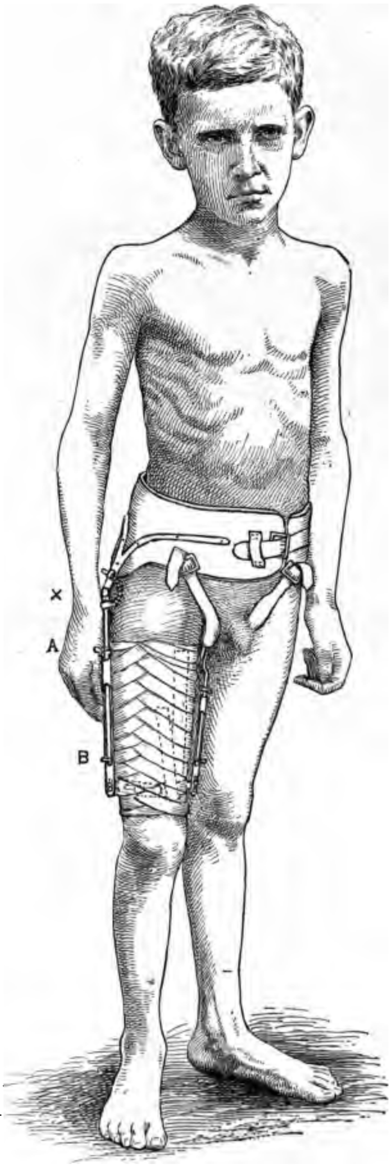

Fig. 9.

Fig. 9.*—Roberts' Short Bilateral Elastic Tension, or Linearly Self-Acting and Atraumatic Hip Splint.

---

* Taken from "The Hip and its Diseases," by V. P. Gibney, A. M., M. D., p. 378. New York, Bermingham & Co., 1884.

or copper, covered with leather on the outside and thoroughly upholstered on the inside. It is broad, and to secure a good fit, is fashioned over a plaster cast of the patient's pelvis. The femoral segment of the instrument is composed of two compound side bars with their elastic attachments and a broad metallic ring which encircles the distal end of the thigh. The side bars extend down along the thigh upon its inner and outer aspects. They are so constructed as to exert continuous elastic linear traction upon the thigh.

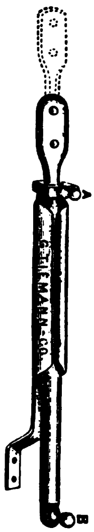

Fig. 10.—A Single Pair of Roberts' Elastic Tension, or Linearly Self-Acting and Atraumatic Elements.

The mechanism by means of which this is accomplished can be understood by reference to Fig. 10. One compound side bar or single pair of kinematic elements is here represented. It consists of two light bars of steel, one of which is provided with expanded margins which have been turned over so as to form a shell through which the other bar slides, and by means of which the relative position of the two bars to each other is maintained. The upper or proximal end of this bar is converted into a rectangular loop which completely closes over the sliding bar, and on the summit of this a brass pin is soldered. Figs. 9 and 10 A. The sliding bar is also provided with a brass pin at its lower or distal end, B. Any force which brings these two pins nearer together, must of necessity lengthen the instrument, as shown by the dotted line in the figure. It must also as a consequence, exert a tractile force upon the joint over which it extends, when properly attached to the limb. In order to make this tractile force elastic, or in other words, like manual traction, a narrow strip of strong elastic webbing, provided at one end with a button-hole, is slipped over the brass pin, at A. To the pin B, which is *screwed* in to the opposing end of the other bar, a buckle is attached. The instrument having been applied and secured in position by means of adhesive plaster and roller bandages, with the brass pins at the greatest possible distance apart, we can, by means of the elastic webbing and buckle, exert any desired amount of continuous elastic force. By tightening the elastic webbing the ends of the bars bearing the pins are drawn nearer together and the opposing attached ends of the bars are pushed further apart. It is in this way that the traction force is graduated. By substituting a *non-elastic* strip for the elastic one, ***fixed or rigid*** traction could be maintained by the same mechanism. The distal end of the bar with expanded margins is attached to the metallic band which encircles the limb just above the knee. This band is secured in position by means of strips of strong adhesive plaster placed longitudinally around the thigh with their lower ends turned up over it (the band) and retained in position by another bandage, (see dotted lines, Fig. 9). The ring is thus prevented from being pushed down over the knee when traction is made as above described.

At ×, Fig. 9, a simple hinge-joint connects the outer side-bar with the pelvic segment. Passing over this joint in front is a semi-circular rod upon which a coiled steel spring is placed, the action of which is to oppose flexion of the thigh on the abdomen. An adjustable nut on the curved rod furnishes the surgeon with the means of exercising his discretion as to how much motion at the joint shall be permitted. A ball-and-socket joint connects the proximal end of the inner side-bar with an upholstered perineal saddle, which latter device is connected with the pelvic segment by means of two straps, one passing up anteriorly, the other posteriorly. A perineal strap on the unaffected side passes to the pelvic segment in front and behind. These two joints permit of the movements of flexion, and extension at the hip, during locomotion, and in changing from the standing to the sitting posture or the reverse.

For the purpose of introducing into the instrument the movements of abduction, adduction and rotation, I have made use of the ingenious ratchet-clamps of Dr. Chas. F. Stillman, Fig. 11, A. B. They are placed just above the simple hinge-joint connecting the femoral with the pelvic segment. The clamp A is so placed as to permit of the movements of abduction and adduction, while the clamp B, permits of rotation movements. That the movements of abduction and adduction permitted by the clamp A shall be free requires the introduction of a simple hinge joint at the distal end of the inner side-bar, connecting it with the band that encircles the thigh, and so placed as to permit of lateral movements and oppose movements in the extenso-flexor plane of the instrument. By means of a key the ratchet clamps are opened so as to permit of placing the femoral segment of the instrument in any desired relative position to the

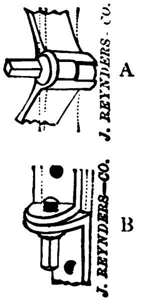

Fig. 11.—Stillman's Ratchet Clamps.

pelvic segment; they are then closed, and the desired position maintained.

The splint as applied is represented in Fig. 9, and it will be seen that no joint, save the one diseased, is restricted in its normal movements. Nature's protective attitudes which our studies have served to call attention to, can be assumed by the patient whenever occasion presents, and he is thus freed from the perils which are forced upon those patients who have the joints of their disabled member immobilized, by lashing it to a heavy rigid iron or steel shaft extending the whole length of the limb.

The sustaining power of this apparatus lies in its elastic attachments, and not in the steel side-bars, or other metallic parts. The office of the sliding side-bars or reciprocal kinematic elements on the inner and outer aspects of the thigh, is only to give direction to the force exerted by the elastic side straps. The vibratory impulses, resulting from the impact of the foot on the ground, which are transmitted to the metallic side-bars, are not conducted through them to the perineum and pelvic segment, as with rigid traction instruments, but are *received upon the tense strips of elastic webbing* attached to the side-bars, preventing further upward progress. Our compound side-bars, or kinematic elements, thus form an *atraumatic* mechanism of great practical value, being constructed upon scientific principles, based upon the laws of impact and the rectilinear transit of vibratory impulses. To still further reduce the jar incident to locomotion, I require my patients to wear soft rubber heels on their shoes.

There is also a mechanical advantage secured in the construction of the instrument. It is this:—The strain being transferred from the side-bars to the elastic straps instead of being borne by the metallic shafts, as with rigid traction splints, permits of the construction of a much lighter instrument of equal durability with the heavier iron and steel ones. Easy portability is thereby secured at no sacrifice. Another advantage which this instrument possesses over those which project below the foot, is that the patient is permitted to place his foot upon the ground in walking, the same as in health, thus preserving the foot-sense, which, as everybody knows, is of the greatest possible service as a sentinel against unpleasant or disastrous jars and traumatisms. The great value of the foot-sense in this regard is particularly well illustrated in the use made of it by the blind to detect unevenness of the surface walked upon, and by the deaf, or deaf and dumb in signalizing the approach of moving vehicles.

The continuous *elastic* traction exerted by the instrument, like *manual* traction, permits of articular motion without intra-articular pressure or friction, and without giving rise to the slightest discomfort to the patient. The linear traction in conjunction with the circumfemoral compression incident to bandaging are the agents relied upon for the subduction of reflex muscular spasm, and the restoration of the reflexly contracting muscles to voluntary use.

Without going into a consideration of the metabolic dynamics concerned in the cure of hip disease, or studying in detail the transmuting conditions upon which the converting of pathological processes into recuperative or physiological processes depend, it must be patent to all, that by thus placing the disabled joint in a condition closely approximating that which we find in health, we avoid the depreciating influences which prolonged immobilization necessarily has on the local nutrition, we facilitate the circulation of the blood through the limb, and thereby secure for the joint, blood which is better oxygenated, together with a proper temperature, and other concomitant conditions favorable to the growth and development of adjacent parts, and the repair of diseased tissues.

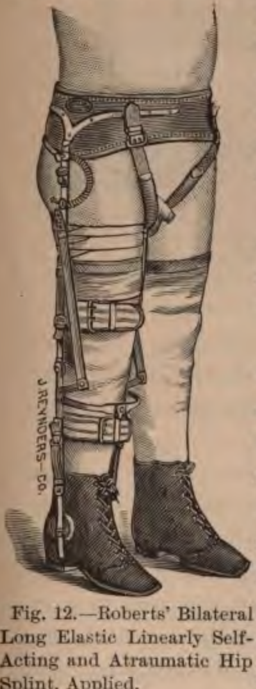

Fig. 12.—Roberts' Bilateral Long Elastic Linearly Self-Acting and Atraumatic Hip Splint, Applied.

The same principles of treatment can be enforced and greater supporting power afforded the patient by the employment of the long splint shown in Figs. 12 and 13.

It consists, as will be seen by reference to Fig. 13, of four segments respectively corresponding to the pelvis, *a*, thigh, *b*, leg, *c*, and foot, *d*. The pelvic and femoral segments are identical in construction with the corresponding parts in the short splint, Fig. 9. Like the short splint, this instrument is constructed to exert *elastic linear traction*, the mechanism for accomplishing this is the same as that in the short splint, see Fig. 10. In the long splint,

LANE LIBRARY

however not only the femoral segment, but that of the leg is provided with compound or sliding bars for exerting elastic traction. At *b′ b″* are shown the pins which are secured to the free ends of the sliding bars, to which the elastic side strap is attached. The side bar upon the inside of the thigh together with the side bars upon the inner and outer aspects of the leg are similarly constructed and provided with pins and strips of elastic webbing. At *b‴* is an universal joint, as in the short splint, connecting the inner side bars with the upholstered perineal saddle.

From the side-bars up the splint, just below and in front of the knee, there extends from one to the other a light but strong semi-circular metallic band. Attached to the middle of this is an adjustable arm projecting downward in a line with the spine of the tibia *c″*. From this arm as a fixed point there extends a broad elastic band around the leg behind the head of the tibia, see Fig. 12, which serves to keep the instrument constantly in the same relative position to the limb.

From the semi-circular piece on either side at the points of its attachment to the lateral shafts of the splint, there projects directly forward a metallic arm, *c′* Fig. 13, curved upward. To the end of these levers are attached strong strips of elastic webbing which pass up through a buckle attached to the pin *b′* and the corresponding one on the inner shaft. These elastic straps, one on either side, are designed to supplement the function of the quadriceps extensor muscle.

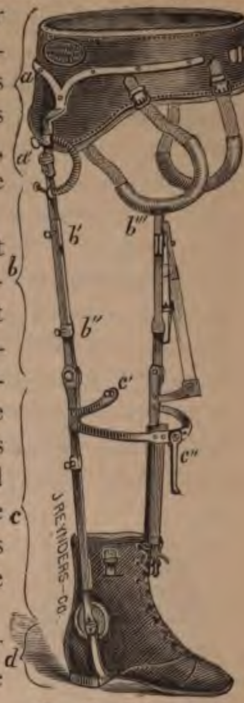

Fig. 13.—Roberts' Long Bilateral Elastic Tension, or Linearly Self-Acting and Atraumatic Hip Splint, showing mechanism.

At the junction of the leg with the foot segment, a French joint on either side permits of their disarticulation, a matter of great convenience in the application and removal of the splint. At the suggestion of Dr. F. C. Williams, of Cheshire, Conn., I have this joint now made with a revolving pin which is kept from turning, when the joint is locked, by means of a flat steel spring. By pressing upon the spring and releasing the pin it can be turned so as to disjoint the foot from the leg segment in any position whatsoever. This is a great practical gain over the ordinary French joint.

In the application of the instrument, long strips of adhesive plaster are used in precisely the same manner as in the application of a Davis, Taylor or Sayre hip splint, the lower ends tipped with non-elastic webbing passing through buckles attached to the shoe on either side. The shoes worn by hip-diseased patients should fit the feet well, be made to lace instead of button, and provided with a low, broad heel of soft rubber.

Do the Appliances above described Permit of the Practical Enforcement of the Therapeutic Ideas which have been the outgrowth of our Studies?—While we have undoubtedly made commendable progress in the mechanical appliances for the execution of our therapeutic ideas, we must not hesitate to interrogate ourselves at every turn regarding the practical realization of our views. The question, therefore, now presents itself: Do the appliances above described permit of the practical enforcement in the most agreeable manner of the therapeutic ideas which have been the outgrowth of our clinical, pathological and physiological studies? Let us see. We have very thoroughly protected the diseased area from traumatisms; we have furnished sufficient artificial sustentation to counterbalance the loss of supporting power on the part of the disabled member; we have prevented undue intra-articular pressure and friction; we have nullified reflex muscular spasm; we have restored voluntary muscular motion; we have placed the movements of the limb under the control of the surgeon; we have permitted an approach, on the part of the disabled articulation, to its functional activity, thus promoting the general and local nutrition; we have furnished a linearly self-acting traumatic-proof instrument; we have not interfered with the performance of the functions of healthy joints; and, finally, we have furnished an apparatus of easy portability.

A critical survey of the field, however, will show:

1. That, although we have exerted elastic linear traction by means of the side-straps, and rendered the movements of flexion and extension at the hip auto-adjustable by means of an elastic force exerted by a coiled spring, (Fig. 9 ×, 12 and 13,) we have not rendered the movements of abduction and adduction auto-adjustable, and controllable by spring pressure.

2. The rotatory movements, like those of abduction and adduction, can occur only when the surgeon takes the key and loosens the ratchet clamp; at all other times these movements are prevented, for the position of the femoral segment, with respect to pelvic segment, having been determined upon, the ratchet clamps are tightly closed.

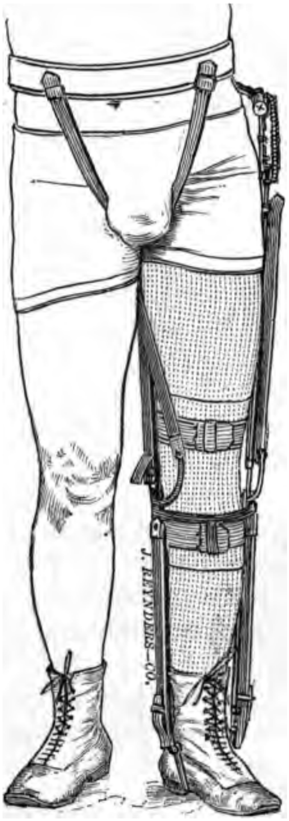

Fig. 14—Roberts' Long Bilateral and Universally Self-Acting, Atraumatic, or Elastic Tension Hip Splint; Front View; Applied.

3. In overcoming reflex muscular spasm by the conjoint use of traction and circumfemoral compression, it will be observed, that while the linear traction force is developed by means of elastic straps, the circumferential pressure is effected by an ordinary muslin roller bandage, which does not exert continuous elastic force, and hence is not a good substitute or close imitation of manual compression.

To realize the practical fulfillment of the above ideas has cost me much additional thought and mechanical experimentation, to say nothing of the great expenditure of time and money. I will not weary you with constructive details, but will content myself for the present with giving a general idea of the means employed.

Figs. 14 and 15 illustrate the instrument which I have invented to supply the deficiencies in my earlier instruments, as already pointed out and tabulated above. Above the hinge joint of the instrument, opposite the hip joint, is placed a double cylindrical box joint containing narrow strips of spring steel placed longitudinally within the inside cylinder. This joint is so placed as to permit of the movements of abduction and adduction. It is so constructed as to be perfectly adjustable, and automatically restore the position of the limb by the continuous exercise of spring pressure. To the outer side-bar of the femoral segment is attached an adjustable elastic tension rotary mechanism. It consists of a long flat steel spring attached to the distal end of the proximal rod of the outer femoral side-bar and secured at its upper or proximal end

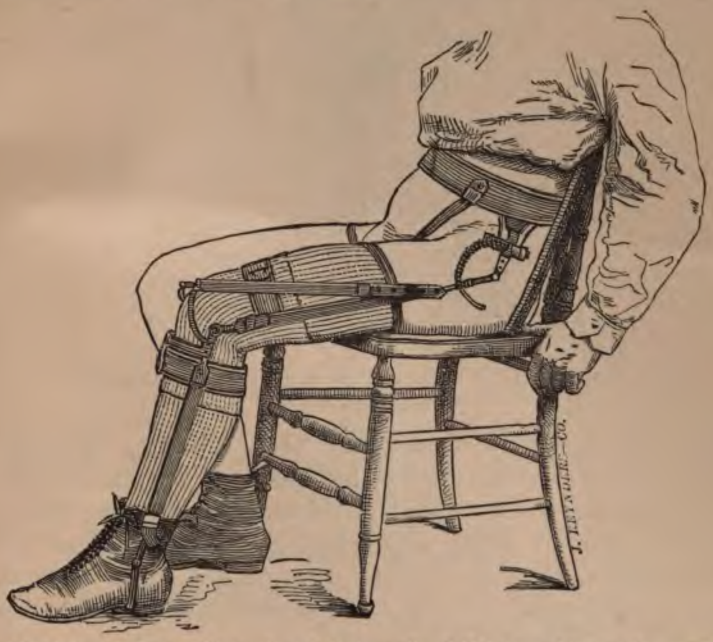

FIG. 15—Roberts' Long Bilateral and Universally Self-Acting Atraumatic, or Elastic Tension Hip Splint; Side View; Sitting Posture.

by being passed through an adjustable nut situated above a horizontal swivel-joint in the line of the proximal rod and just below the hinge-joint, opposite the joint of the hip.

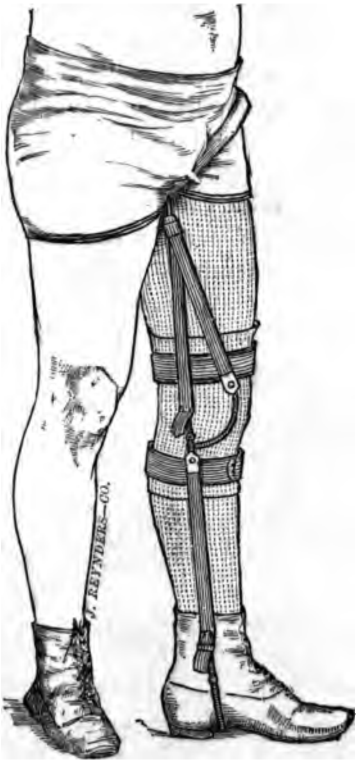

FIG. 16—Roberts' Inside Elastic Tension, or Self-Acting Atraumatic Hip Splint, Applied.

Either the inside or outside shaft of this instrument may be used alone for the treatment of hip disease. Fig. 16 illustrates the appearance, when applied, of the inner shaft thus employed.

Fig. 15, though really representing my long bilateral hip splint, gives a good idea of the appearance, when applied, of the external shaft of the same when used alone for the treatment of hip disease.*

---

* Of course, it will be understood, that when the surgeon desires it for economy or other purposes, any of the above described splints may be simplified in construction, by omitting the elastic abducting and adducting joint, the elastic rotating mechanism, and, finally, the semi-circle upon which a coiled spring is placed. What I am aiming at in this paper is a full practical realization and enforcement of the theoretical indications for treating hip disease.

Finally, I have invented an adjustable flat-box joint containing a coiled spring which enables me to do away with the semicircular piece opposite the hip joint, and also the metallic arm attached to the side bar just below the knee, c' Fig. 13, together with the elastic strap secured to its free end. By means of this joint I secure in a much more elegant and workmanlike manner, all the advantages which accrue from the use of the dispensed mechanisms. Fig. 17, illustrates the appearance of this joint when introduced into the outer shaft of my bilateral instrument, and used above for the treatment of hip disease.

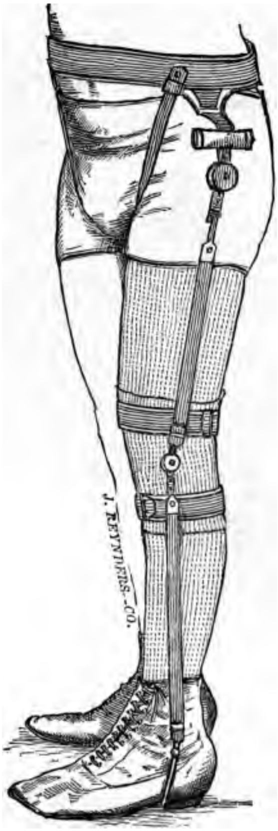
J. REYNDERS-CO.

Fig. 17.—Roberts' Outside Elastic Tension, or Self-Acting Atraumatic Hip Splint, with Adjustable Spring Box Joints and Elastic Rotating Mechanism.

In the application of all these instruments the muslin roller bandage used in securing the adhesive strips in place and making circumferential pressure, has been replaced, by silk elastic encasements for the leg, thigh and knee. *Elastic* circumferential pressure has thus been secured.

Having now realized the practical fulfillment of all the theoretical therapeutic indications adduced from our studies, let me assure you, that, in so far as my experience in the treatment of hip disease and the analogous diseases of other joints teaches anything, it goes to show that the remedial path which has been pointed out in this paper will ere long be accepted as the first scientific solution of the therapeutic problem in hand.

LANE MEDICAL LIBRARY

To avoid fine, this book should be returned on or before the date last stamped below.

M682 Roberts, M. J. 161
R64 The fundamental pri
1885 ples of mechanico-t
apy in hip disease

NAME	DATE